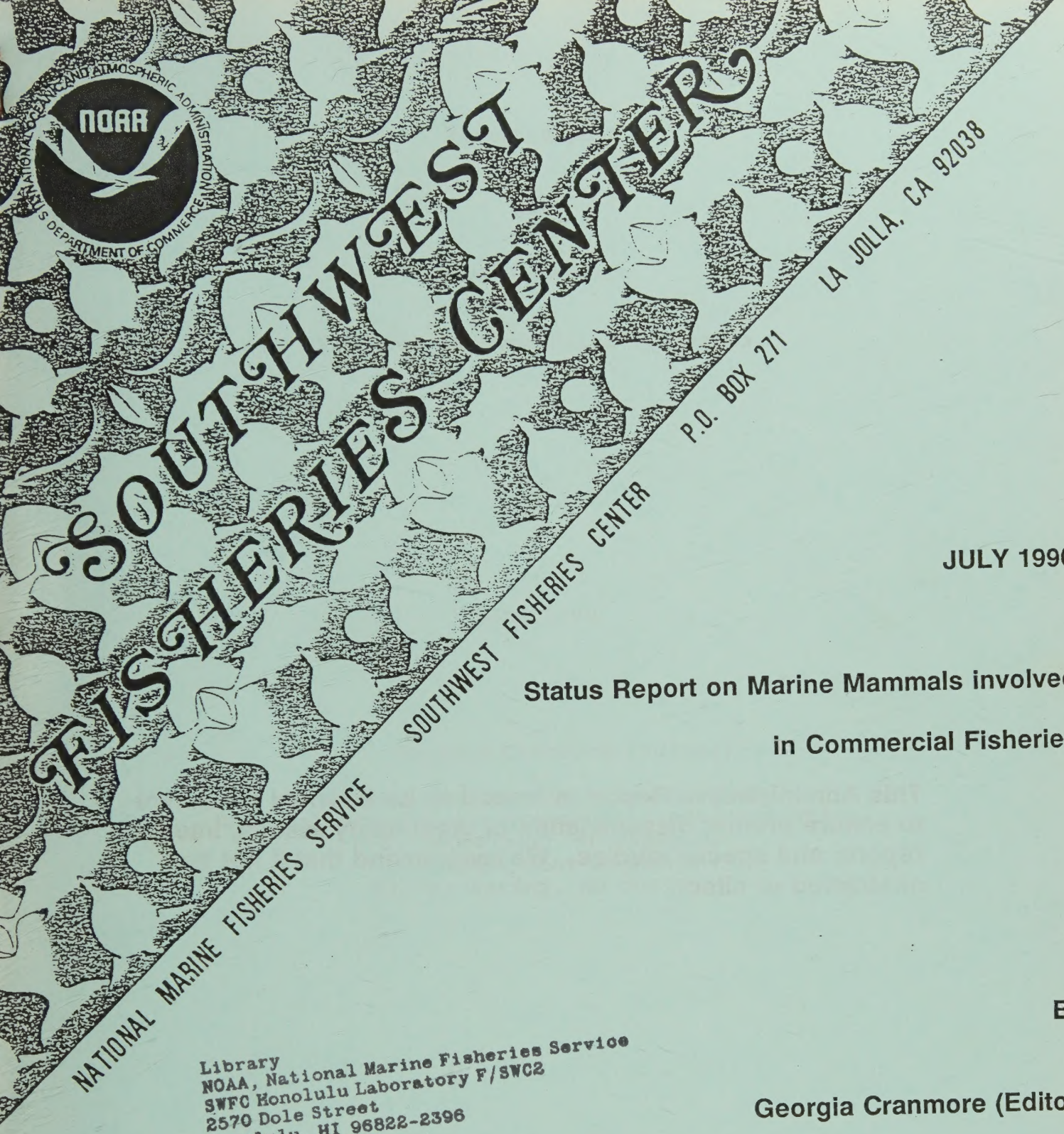

JULY 1990

Status Report on Marine Mammals involved in Commercial Fisheries

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By

Georgia Cranmore (Editor)

ADMINISTRATIVE REPORT LJ-90-19

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Status Report

on

Marine Mammals

Involved in Commercial Fisheries

June 1990

Georgia Cranmore (Editor)

National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
1335 East-West Highway
Silver Spring, MD 20910

ADMINISTRATIVE REPORT LJ-90-19

Preface

Marine mammals become entangled in active fishing gear and may be injured or killed. This "incidental take" is an exception to the moratorium placed on the taking and importation of marine mammals by the Marine Mammal Protection Act of 1972 (MMPA), 16 U.S.C. 1361-1407:

> Marine mammals may be taken incidentally in the course of commercial fishing operations and permits may be issued therefore under section 104 subject to regulations prescribed by the Secretary in accordance with section 103. In any event it shall be the immediate goal that the incidental kill or incidental serious injury of marine mammals permitted in the course of commercial fishing operations be reduced to insignificant levels approaching zero mortality and serious injury rate; *** (Sec. 101(a)(2)).

This exception is not available, however, for species or population stocks that are found to be "depleted". The MMPA defines "depleted" to mean, among other things, any case in which:

> *** the Secretary, after consultation with the Marine Mammal Commission ***, determines that a species or population stock is below its optimum sustainable population *** (Sec. 3(1)(A)).
>
> *** a species or population stock is listed as an endangered species or a threatened species under the Endangered Species Act of 1973 (Sec. 3(1)(C)).

Optimum sustainable population (OSP) means:

> *** the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element (Sec. 3(8)).

The National Marine Fisheries Service (NMFS) defined OSP, in its regulations implementing the MMPA, as a range of population levels from the largest supportable within the ecosystem (carrying capacity) to the population level that results in maximum net productivity (MNP). MNP is the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and growth, less losses due to natural mortality (50 CFR 216.3). It is important to note that carrying capacity is not necessarily the "all-time high" population level. Carrying capacity means the maximum population level that the ecosystem can support at equilibrium, or the mean number of animals in a population undergoing natural fluctuation about the level supportable by the environment.

NMFS has attempted to estimate population status relative to OSP for certain marine mammal populations in several ways. Historic abundance estimates or back-calculations from harvest data are used to estimate carrying capacity (largest supportable population levels) when data are available and it is reasonable to assume that carrying capacity has not changed substantially. Data generally have been insufficient to calculate MNP levels and, following the precedent established by determinations made in 1976 concerning the status of porpoise stocks affected by the yellowfin tuna purse seine fishery, it has been assumed that populations which are 60 percent or more of their carrying capacity level are above the lower limit of the optimum range. A review of the literature on population dynamics of large mammals shows that there is a tendency to exhibit greatest productivity (rate of population change) at population levels that are close to the mean naturally occurring levels (or the carrying capacity of their natural environments). Large mammal populations appear to grow most rapidly (in numbers per unit time) at levels greater than 50% of carrying capacity, some at 80% or higher.

An alternative method used to estimate population status relative to OSP involves a dynamic response analysis. The dynamic response method has been applied to populations for which there are no reliable estimates of historical abundance. This method analyzes trends in abundance (e.g., pup counts) over time and looks for changes in the rate of change that can be attributed to density-dependent factors. Theoretically, this method can detect when a recovering population passes its MNP level, assuming that the carrying capacity is constant or varies in known ways.

To assess the impact of additional mortality factors on the status of marine mammal populations, annual recruitment rates have been compared, in certain instances, to the estimated mortality rates in fishery operations. In the absence of carrying capacity or MNP estimates, this comparison can indicate whether or not the population can continue to increase despite fishery-related mortality.

The following species or population stocks, under the jurisdiction of the Department of Commerce, have been designated as depleted under the MMPA:

North Pacific fur seal, *Callorhinus ursinus*, Pribilof Island population
Hawaiian monk seal, *Monachus schauinslandi*
Bowhead whale, *Balaena mysticetus*

Northern (Steller) sea lions, Eumetopias jubatus, will be proposed for depleted status shortly (See 53 Fed. Reg. 16299, May 6, 1988).

In addition, those marine mammals listed as threatened or endangered under the Endangered Species Act of 1973, 16 U.S.C. 1531-1543, are, by definition in section 3(1) of the MMPA, depleted species:

Gulf of California harbor porpoise, *Phocoena sinus*
Blue whale, *Balaenoptera musculus*
Bowhead whale, *Balaena mysticetus*
Fin whale, *Balaenoptera physalus*
Gray whale, *Eschrichtius robustus*
Humpback whale, *Megaptera novaeangliae*
Right whale, *Balaena glacialis*
Sei whale, *Balaenoptera borealis*
Sperm whale, *Physeter catodon*
Caribbean monk seal, *Monachus tropicalis*
Guadalupe fur seal, *Arctocephalus townsendi*
Hawaiian monk seal, *Monachus schauinslandi*
Mediterranean monk seal, *Monachus*

Status Report
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Summary

The Status Report summarizes species accounts for those marine mammals known to be involved in commercial fishing operations. Separate accounts have been prepared, as appropriate, for Atlantic Ocean and Pacific Ocean stocks and the following topics are considered for each species: (1) stock definition, (2) distribution, (3) population estimates, (4) incidental take in fishery operations, (5) optimum sustainable population (OSP), (6) effect of incidental take on OSP, and (7) research needs.

The following species are discussed:

California sea lion, *Zalophus californianus*
Northern (Steller) sea lion, *Eumetopias jubatus*
Northern (North Pacific) fur seal, *Callorhinus ursinus*
Harbor seal, *Phoca vitulina*, Pacific and Atlantic
Northern elephant seal, *Mirounga angustirostris*
Spotted seal, *Phoca largha*
Harbor porpoise, *Phocoena*, Pacific and Atlantic
Dall's porpoise, *Phocoenoides dalli*
Bottlenose dolphin, *Tursiops truncatus*, Pacific and Atlantic/Gulf
Common dolphin, *Delphinus delphis*, Pacific and Atlantic
Pacific white-sided dolphin, *Lagenorhynchus obliquidens*
Atlantic white-sided dolphin, *Lagenorhynchus acutus*
Northern right whale dolphin, *Lissodelphis borealis*
Short-finned pilot whale, *Globicephala macrorhynchus*
Long-finned pilot whale, *Globicephala melas*
Risso's dolphin, *Grampus griseus*, Atlantic
Beluga whale, *Delphinapterus leucas*
Minke whale, *Balaenoptera acutorostrata*
Killer whale, *Orcinus orca*
Humpback whale, *Megaptera novaeangliae*, Pacific
Gray whale, *Eschrichtius robustus*

Other species are known to be taken incidental to commercial fishing. However, in some cases little information exists on the extent and effect of interactions. In other cases, it is believed that only a few are taken annually. These marine mammals include: (1) Risso's dolphins in the Pacific, (2) right and humpback whales in the Atlantic, (3) Hawaiian monk seals, (4) minke whales in the Pacific, (5) Bryde's whales, (6) pygmy sperm whales, (7) spinner and spotted dolphins in the Atlantic, (8) false killer whales, (9)

rough-toothed dolphins, (10) ringed and bearded seals. The Status Report does not include discussions of dolphin interactions with tuna purse-seine operations in the eastern tropical Pacific Ocean.

Although OSP estimates have not been developed for most stocks, the following species or stocks involved in commercial fisheries are considered likely to be within the range of OSP: (1) northern temperate offshore stock of the Pacific bottlenose dolphin, (2) certain stocks of Dall's porpoise, (3) the elephant seal, (4) common dolphins, (5) Pacific white-sided dolphins, and (6) northern right whale dolphins.

Of the 21 species considered in the Status Report, only three (northern fur seals, humpback and gray whales) are depleted. However, the Steller sea lion, as noted above, will be proposed for depleted status shortly. In addition, the inshore stock of Atlantic bottlenose dolphins appears to be below OSP as the result of a recent disease epidemic.

California sea lions and the California stock of harbor seals are increasing in numbers and may be at historical peak abundance. However, using dynamic response analysis, the populations appear to be below MNP. This may mean that they are increasing toward a higher carrying capacity.

Among pinnipeds, the Steller sea lion, which is probably below OSP and declining rapidly, is the species of greatest concern regarding the effects of incidental take. Fishery-related mortality is not expected to have an adverse effect on other pinniped species considered.

Among cetaceans, the harbor porpoise stock in the Gulf of Maine may be adversely impacted by current levels of incidental take in U.S. and Canadian fisheries. For the group of bottlenose dolphins found inshore along the U.S. mid-Atlantic region, available data suggest that their abundance may have been reduced more than 50% by a recent disease epidemic. Fishery conflicts, in combination with other human-induced mortality, may be sufficient to prevent that group from attaining OSP. Any incidental mortality in the endangered humpback whale population would be likely to affect its long-term recovery.

Complete and accurate estimates of mortality from the commercial fisheries, and better stock abundance estimates, are the most common research needs for these species. When data are lacking on current and historical abundance, close monitoring of incidental take becomes of primary importance in fulfilling research and management objectives under the MMPA.

Information is needed on the age, sex, and reproductive status of animals incidentally killed or seriously injured to judge the possible biological significance of the incidental take. Reliable

information is also needed on when, where, and how incidental take occurs to identify and judge the effectiveness of ways to prevent or reduce such take.

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California sea lion *Zalophus californianus*

Stock Definition

There are three recognized subspecies of the California sea lion: *Z. c. californianus* (coastal western North America), *Z. c. japonicus* (Sea of Japan, possibly extinct), and *Z. c. wollebaeki* (Galapagos Islands). *Z. c. californianus* is the only subspecies addressed here. The breeding range of the California sea lion extends from San Miguel Island in the Southern California Bight south to Isla Margarita on the Pacific Coast of Baja California Sur, Mexico and into the Gulf of California (Mate 1977; Aurioles et al. 1983; Le Boeuf et al. 1983). Mate (1977) suggested that the Gulf of California population may be distinct, but insufficient information on exchange with the Pacific coast populations is available to support a separation. Likewise, no studies of the exchange between rookeries in the U.S. and Mexico have been conducted to address the distinctness of the population breeding in the Southern California Bight.

Boveng (1988) treated the U.S. breeding population as a separate stock because of the close proximity of the four major U.S. breeding colonies (San Miguel, San Nicolas, Santa Barbara, and San Clemente islands) and the lack of information on the rate of exchange between U.S. and Mexican rookeries. Also, there is a relatively long series of annual pup counts for U.S. rookeries (DeMaster et al. 1982; DeLong et al. 1982; Bonnell et al. 1980; Odell 1971) that were used in his assessment of the status of the stock. Data on abundance of California sea lions in Mexico (Orr et al. 1970; Mate 1977; Le Boeuf et al. 1983) are not sufficient to conduct a population assessment for those animals.

Distribution

During the nonbreeding season, California sea lion males migrate north as far as British Columbia (51°N). Ainley et al. (1978) suggested that northward migration is a near-shore phenomenon, since the high autumn peak of migrating males, characteristic of coastal localities such as Año Nuevo (CA), is much reduced on the Farallon Islands (off San Francisco) which are 50 km offshore. A minimum of 5,500 sea lions migrate northward out of California waters to winter off Oregon, Washington, and southern British Columbia (Brown 1988; Bigg 1985). The southward migration begins in early spring and may occur further offshore, as the Farallon Island population displays a prominent spring peak while the inshore Año Nuevo Island population shows a much smaller increase. Ainley et al. (1978) have suggested that this offshore migration is correlated to the appearance in spring of the Pacific whiting (*Merluccius productus*) off the Farallon Islands. Whiting is a major food item in the diets of California sea lions at the Farallons at that time of year. Somewhat inconsistent with Ainley et al.'s hypothesis is Miller et al.'s (1983) documentation of an increase in abundance of adult male and juvenile sea lions hauled

out on the Monterey Bay breakwater each spring between 1979 and 1981. Miller et al. suggest that the northward migration is diffuse in time and space while the southern migration is concentrated.

The movement of females after the breeding season is less well documented. Bartholomew (1967) suggested that females and their offspring stay near the rookeries until later in the season and then move south of California into Mexican waters; however, females do occur occasionally on Año Nuevo and Southeast Farallon islands.

Population Estimates

Le Boeuf et al. (1983) censused sea lions at most rookeries in California and Mexico in 1979 and 1981. Since there is no time when the entire population is on shore, counts underestimate population size and need to be modified to obtain an estimate of total population size. Le Boeuf et al. (1983) expanded their counts based on assumptions about the proportion of females not hauled out, estimated number of animals at uncensused rookeries, and a correction factor for pups not observed. Their estimate of total population size is 145,000 animals: 16% in the Gulf of California, 46% on the Pacific Coast of Mexico, 35% in southern California, and 3% north of the breeding range.

Boveng (1988) estimated that the California stock comprised 87,000 sea lions. His estimate is based on an expansion of pup count data available from the major southern California rookeries. By choosing extreme combinations of parameters used in the expansion, he produced a range of 67,000 to about 107,000 sea lions.

Adding Boveng's (1988) California estimate to Le Boeuf et al.'s (1983) estimate of the Mexican population yields a total population estimate of 176,900 California sea lions. Since the rate of exchange between Mexican and U.S. rookeries has not been studied adequately and U.S. fisheries likely take California sea lions from the portion of the population that breeds in the Southern California Bight, NMFS is limiting consideration of the effects of fishery interactions to the California stock described by Boveng.

Incidental Take in Fishery Operations

In response to apparently increasing rates of marine mammal fishery interactions, NMFS and state resource agencies began quantifying levels of kill incidental to commercial fisheries. Miller et al. (1983) surveyed most California fisheries between 1979 and 1981. They reported that California sea lions interacted with most commercial fisheries either by damaging gear and catch or by being killed incidental to fishing operations. They estimated 1,492 California sea lions were killed incidental to commercial fishing operations in California in 1980. Of those, nearly 1,200 were taken in ocean gillnet fisheries. The remainder were taken in

purse seine fisheries, trawl fisheries, and troll fisheries. Most of the gillnet related mortality occurred in the drift gillnet fishery for shark that was initiated in 1977. Miller et al.'s estimate of high mortality near rookery islands generated concern about the impact on the sea lion population. In 1982, the State of California enacted seasonal and area restrictions on the fishery to reduce the level of take. As a result of these closures and the changing dynamics in the developing fishery, total sea lion mortality incidental to drift gillnets dropped to an estimated 152 sea lions in the 1985-86 fishing season. Although a decline in total mortality is likely, the estimate of the magnitude of this decline should be considered cautiously because observer coverage during the 1985-86 fishing season was less than 1%.

Since Miller et al. (1983) completed their survey of California fisheries there has been a substantial increase in set net fishing in California (Collins et al. 1984; Collins et al. 1985;, Collins et al. 1986; Wild 1986a,b). Consequently, marine mammal mortality monitoring programs have focused on set net fisheries. Provisional estimates for the 1983-84, 1984-85, and 1985-86 fishing seasons are: 3,658, 2,245, and 2,229 sea lions, respectively. The high mortality estimate in the 1983-84 fishing season may have been associated with increased rates of interaction resulting from poor availability of forage resources during the 1982-83 El Niño event.

As a result of increasing State regulation of the use of gillnets, the number of gillnet fishermen in California has been limited. Therefore, we expect that California sea lion mortality in California gillnets (both set and drift nets) in a typical year is likely to be about 2,250 sea lions. Miller et al. (1983) estimate that about 300 sea lions are shot incidental to the California salmon troll fishery annually and about 40 are taken in round haul (purse seine and lampara net fisheries) and trawl fisheries.

Geiger (1985) estimated that 45 sea lions were taken incidental to the 1981 Columbia River gillnet fishery for salmon. Sea lions also interact with troll fisheries in Washington and Oregon and have been reported taken incidentally at aquaculture facilities in Oregon (NWR/NMFS unpubl. data). No estimate of total California sea lion mortality incidental to commercial fisheries in Oregon and Washington is available.

Summing estimates by Miller et al.(1983), Hanan (pers. comm.), and Geiger (1985) produces a minimum annual mortality estimate of about 2,635 California sea lions.

Optimum Sustainable Population (OSP)

There are no published estimates of California sea lion abundance prior to commercial exploitation of the stock and insufficient information on harvest rates is available to support estimation of pre-commercial harvest abundance (Cass 1985). Therefore,

California sea lion status can not be judged as a proportion of historical abundance.

Boveng (1988) performed a dynamic response analysis on trends in pup counts to assess the status of the California sea lion population. This method (DeMaster et al. 1982; Boveng et al. 1988; Goodman 1988) analyzes trends in abundance over time and looks for changes in the rate of population change that are attributable to density dependent mechanisms of population control. Theoretically, this method can be used to detect when a recovering population passes its maximum net productivity level (MNPL), the lower bound of the range of population sizes considered to be at OSP. The form of the dynamic response method used by Boveng assumes that no major environmental fluctuations affecting carrying capacity occur during the time-series analyzed. Since the El Niño event violates this assumption, Boveng limited his analysis to the interval 1975 to 1982. The results of his analysis indicate that the California sea lion population is below its MNPL.

Other sources of information indicate that the population may have recovered to levels of historic abundance. Seagars et al. (1985) found that nearly all historic rookeries are currently occupied. LeBoeuf and Panken (1977) suggest that the carrying capacity over the last 100 years has increased for northern elephant seals; and these animals are now able to utilize hauling areas from which they were previously excluded by the presence of large, terrestrial predators (e.g., brown bears and wolves). Stewart et al. (in press) have argued that the take of seal lions in southern California by American Indians for subsistence may have maintained the sea lion population at a level below its equilibrium. These studies may explain the apparent contradiction between the fact that the sea lion population is presently increasing, but still occupying its historic range.

Effect of Incidental Take on OSP

Boveng (1988) calculated a per capita population growth rate of 6.4% annually over the period 1971 to 1982. He argues that this is the best available estimate of the current growth rate because higher rates of increase in pup counts observed post El Niño are probably not reliable estimates of population growth. Also, pup counts had returned to 1982 levels by 1986 indicating the population might continue to grow at the pre El Niño rate. Boveng multiplied the rate of increase by population size to obtain an estimate of 5,600 sea lions as the replacement yield for the population. This may be an underestimate of replacement yield because it does not include the incidental mortality that occurred during the years of population increase.

The current estimate of total mortality is well below the replacement yield estimated by Boveng. Therefore, we expect that

the population will continue to grow despite current levels of incidental mortality. Incidental mortality has likely affected the rate of population growth but has not precluded growth toward OSP.

Research Needs

Determine (a) the age, sex, and reproductive status of the animals being killed or injured, and (b) when, where, and how, as well as how many, animals are being caught and killed or injured incidental to fisheries.

A better estimate of mortality in commercial fisheries is needed so adjustments to estimates of per capita production can be made. Accurate estimates of per capita production would improve the accuracy of the dynamic response analysis of population status.

Information on population indices such as age at first reproduction, age specific pregnancy rates, age specific survival rates, and condition indices of individual animals are needed to augment assessments of status.

Information on exchange between U.S. and Mexican rookeries is needed to resolve the definition of stock question.

Data on food habits are needed to assess impacts of the growing sea lion population on recruitment of fish to populations exploited by commercial and sport fisheries.

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Northern (Steller) Sea Lion *Eumetopias jubatus*

Stock Definition

There have been no studies to develop criteria for separating the geographic regions into separate populations based on any biological parameters. The breeding range of northern sea lions extends around the North Pacific Ocean rim from the Kuril Islands and Okhotsk Sea, through the Aleutian Islands and southern Bering Sea, along Alaska's southern coast, and south to California (Kenyon and Rice 1961; Loughlin et al. 1984). The centers of abundance and distribution are the Gulf of Alaska and Aleutian Islands, respectively. Rookeries are dispersed from the central Kuril Islands (46°N) to southern California (37°N). Most large rookeries are in the Gulf of Alaska and Aleutian Islands (Calkins and Pitcher 1982; Kenyon and Rice 1961; Loughlin et al. 1984; Merrick et al. 1987).

Distribution

Northern sea lions are not known to migrate but disperse widely during the postbreeding season and may occur near ice or northern islands in the Bering Sea during fall and winter (Kenyon and Rice 1961; Loughlin et al. 1984). Animals branded at various Gulf of Alaska rookeries have been sighted in southeast Alaska; some marked in British Columbia were seen at Cape St. Elias, Alaska; some tagged in the eastern Aleutians were seen in eastern Bristol Bay, Alaska, and some marked in Oregon were seen in southeast Alaska. Since individual animals disperse widely after the breeding season and intermix with animals from other areas, it would be difficult to identify individual animals once away from the rookery as belonging to a specific reproductive population.

Adult breeding animals and some subadults occupy rookeries during the breeding season, which extends from late May to early July (Pitcher and Calkins 1981). Nonbreeding males, some subadults, and transient females may be seen at separate haul out sites. Rookeries and haul out sites are generally characterized by minimal disturbance, access to the sea, and local abundance of food (Mate 1973).

While feeding at sea, northern sea lions frequently are seen near shore and out to the continental shelf; in the Gulf of Alaska they commonly occur near the 200 m depth contour (Kajimura and Loughlin in press). They have been caught on fishing lines at depths of 183 m (Fiscus and Baines 1966; Kenyon 1952); some individuals may enter rivers in pursuit of prey (Jameson and Kenyon 1977). During the breeding season females remain on land during the day and feed principally at night; territorial males remain on land and fast during the breeding season (Gentry 1970; Spalding 1964; Withrow 1982).

Population Estimates

The total number of adult animals in the Gulf of Alaska and Aleutian Islands represents about 75% of the world population (Gulf of Alaska = 38%; Aleutian Islands = 37%); however, the proportion is changing as the Alaskan population declines in number (Braham et al. 1980; Merrick et al. 1987). Seal Rocks in Prince William Sound, Alaska, represents the northern-most rookery (60°09'N) and Año Nuevo Island off central California is the southern-most rookery (37°06'N). There are no longer any northern sea lion pups born at San Miguel Island, California, once the most southern rookery.

Population estimates for northern sea lions are usually based on counts of animals hauled-out on land, principally during the breeding season. The optimal dates to census northern sea lions are between mid-June and mid-July when 90% or more of the animals hauled-out are present; the optimal times during this period are between 1000 and 1800 hours (Withrow 1982).

The number of sea lions in southwestern Alaska, which included at least 140,000 animals around 1958, totaled less than 68,000 in 1985--a decline of 52% in 27 years. As discussed in Merrick et al. (1987), regional numbers, breeding animals on rookeries, pup production, and data from specific island rookeries confirm this decline. The population at Ugamak Island in the eastern Aleutian Islands showed no decline between 1957 and 1969, and then declined at least 10.1% per year between 1969 and 1986. This implies that the eastern Aleutian Island population may have begun to decline in the early 1970s (Braham et al. 1980).

Numbers have declined throughout much of the Alaska region, with the greatest declines in the eastern Aleutian Islands (-79%) and western Gulf of Alaska (-73%), but declines have also occurred in the central Gulf of Alaska (-31%) and central Aleutian Islands (-8%).

The observed declines may have occurred in two phases. The first phase probably began in the early 1970s and was confined to the eastern Aleutian Islands and western Gulf of Alaska. Numbers for most of the Aleutians and Gulf of Alaska fell by 25% (-1.6% per year) between 1958 and 1977. Numbers in the eastern Aleutian Islands appeared to stabilize in the mid-1970s, while those in the central Aleutian Islands and western Gulf of Alaska may have increased slightly. Those increases and the state of knowledge on abundance at other locations indicated that the world-wide population had not changed appreciably between the late-1950s and late 1970s (Loughlin et al. 1984). A second phase of the decline probably began during the late 1970s, with all areas being affected and overall numbers falling 36% (-5.2% per year) between 1977 and 1985. Counts of adults and pups at Marmot Island during 1986 and 1987 indicate that the decline is continuing. The number of pups

counted at Marmot Island in 1979 was 6,741. In 1986 the number of pups at Marmot Island declined to 4,286, and in 1987 the count was only 2,910.

Numerical decreases in northern sea lion abundance have been noted at the western extent of the breeding range in the Kuril and Commander Islands (Chelnokov 1984; Perlov 1982). Numbers began to fall in this region in about 1972, and by 1981-82 had fallen by 50% or more. Abundance at sites in the western Aleutian Islands declined 34-61% from 1979 to 1985 (Klett in Merrick et al. 1987). Adult sea lions at Walrus Island (Pribilof Islands) have declined from 4,000-5,000 animals in 1960 to about 600 in 1982 (Kenyon 1962; Loughlin et al. 1984). Pup production at Walrus Island fell from 2,866 in 1960, to about 334 in 1982, and less than 200 in 1987. There are about 5,700 northern sea lions in British Columbia and 5,410 in the lower United States (Washington, Oregon, and California); the population levels there do not appear to be changing (Loughlin et al. 1984).

There are no increases in abundance reported for any rookery that could account for the observed declines or that indicate a geographical shift in population distribution.

Incidental Take in Fishery Operations

Many northern sea lions are taken incidental to commercial fishing operations in the Bering Sea and North Pacific Ocean. In 1978-1981 the estimated annual mortality for all foreign vessels was 724 animals (Loughlin et al. 1983). This does not include animals taken by U.S. fishermen fishing in joint ventures or independently. Loughlin and Nelson (1986) documented the incidental take of sea lions in the Shelikof Strait (near Kodiak Island, Alaska) walleye pollock (Theragra chalcogramma) joint venture fishery where an estimated 958 to 1,436 sea lions were caught by U.S. trawlers in 1982. This take declined to less than 400 per season in 1983 and 1984, probably due to changes in fishing technique and the area and times fished. Less than 100 per year were taken during 1985 to 1987 as the fishery diminished in total fish take and effort. The cumulative impact of foreign and joint venture fisheries in the Bering Sea and North Pacific Ocean probably now accounts for less than 500 northern sea lion deaths per year by incidental take. As foreign fishing is phased out of U.S. waters, the domestic take will probably replace that of the foreign take but is not expected to surpass it.

It is unclear how directed killing of sea lions by fishermen has affected the population. Fishermen have been observed to kill adult animals at rookeries, haul out sites, and in the water near boats, but the magnitude of this take is generally unknown (Merrick et al. 1987). One of the few estimates of shooting mortality is reported by Matkin and Fay (1980) who calculated that 305 northern sea lions were killed directly (shot) while interfering with

fishing operations in the spring 1978 Copper River Delta salmon gillnet fishery. During the 1960s, northern sea lions at sites in the eastern Aleutian Islands were prime sources of bait for crab fishermen. This killing may have had a significant effect on local populations and might have caused animals to move away from traditional rookeries and haul out sites (Loughlin and Nelson 1986; Merrick et al. 1987). Small numbers have been reported taken off St. Georges Reef (Oregon-California; NMFS/NWR unpubl. data).

Commercial or Subsistence Harvest

Northern sea lions were commercially harvested in the eastern Aleutian Islands and Gulf of Alaska from 1952 to 1972 (Merrick et al. 1987). Six hundred and sixteen adult males were taken in an experimental harvest in 1959 (Thorsteinson and Lensink 1962). A total of 45,178 pups of both sexes were harvested in the eastern Aleutian Islands and Gulf of Alaska between 1963 and 1972 (Merrick et al. 1987). The largest harvests were conducted between 1963 and 1972 at Sugarloaf and Marmot Islands where 16,763 and 14,180 pups, respectively, were killed, and between 1970 and 1972 at Ugamak and Akutan Islands where 3,773 and 6,036 pups, respectively, were killed. The pup harvests, which sometimes reached 50% of the total pup production from a rookery (e.g., at Sugarloaf Island in 1965 and 1968), could have depressed recruitment in the short term. This may partially explain some of the declines experienced at some sites through the mid-1970s. However, it is unclear why numbers declined in areas where no harvest occurred (Merrick et al. 1987).

Presently, subsistence take of northern sea lions occurs at St. Paul Island, Pribilof Islands, where Aleut natives take about 50 sea lions for food. About 10 are reported taken at Alakanuk, an unknown number at Unalaska and Atka, and more than 400 are reported taken in the Kodiak area, although the take at Kodiak has not been substantiated (Schroeder et al. 1987).

Entanglement in Debris

There are few data on the impact of entanglement on northern sea lions. Two studies, one in the Gulf of Alaska (Calkins 1985) and the other in the Aleutian Islands (Loughlin et al. 1986) have documented the occurrence of sea lions entangled in packing bands and net fragments. However, the observed rates of entanglement are not sufficient to account for observed declines. There are insufficient data to describe the effect on pups and juvenile animals since they are infrequently observed entangled; entangled animals may die at sea and thus are not counted on land. However, based on existing information it seems unlikely that the observed declines are caused solely by entanglement in debris.

Optimum Sustainable Population (OSP)

The current population level of northern sea lions in most of Alaska (68,000) is about 48% of the population level during 1956-1960 (140,000). If the 1956-1960 population is assumed to have been at carrying capacity (K), and maximum net productivity level (MNPL) is 50% of K, then at least 70,000 adult sea lions would be required to attain maximum net productivity. But as Fowler (1984) pointed out, MNPL is probably higher for large-mammal populations. If MNPL were 80% of K, then 112,000 animals would be required for maximum net productivity. Assuming then that the population was at K during 1956-1960, the range of population levels for OSP at MNPL equal to 50% is 70,000 to 140,000; for MNPL equal to 60% the range is 84,000 to 140,000; and for MNPL equal to 80% the range is 112,00 to 140,000. Estimates for the current population and the MNPL at 50% are virtually the same (2,000 animals difference); the accuracy of counts could easily account for the difference. However, the 1956-1960 counts probably underestimated sea lion numbers. This difference is likely greater than the difference in missed animals at sea during the more recent surveys. Consequently, estimated K and MNP levels for those years when counts were made early in the year should be adjusted upward resulting in the current population level being below OSP. The available data do not support the hypothesis that the earlier counts were too high and overestimated the population level.

It is possible that the carrying capacity of the marine environment has declined gradually over the last 15-20 years and that sea lions numbers declined in proportion to reduced K. If this hypothesis is true, then the sea lion population has probably remained within OSP levels and may currently reflect a lower carrying capacity. However, there are no data indicating that a change has occurred in the carrying capacity which would result in reduced numbers of sea lions. In addition, individual animals appear robust, suggesting an ample supply of food is available. Our ability to measure carrying capacity is primitive at best and most inferences on levels of K are therefore only circumstantial.

Another, less likely, possibility is that the earlier population was above K resulting from plentiful food supplies in the Bering Sea during the 1960s. As food supplies diminished to lower levels after the early 1970s, the sea lion population then declined and began to stabilize at levels at or just below K. Surveys during the 1960s would have documented the population while at the highest level and subsequent surveys noting the decline would have documented the population as it began to stabilize around the new K level. However, no increases have been noted in any areas (except for an increase in the central Aleutian Islands during 1979) which would indicate a population that dropped below K and is adjusting upward toward K, as would be expected as a population stabilizes at the new K. Presently the trend in all surveyed areas in Alaska shows a constant decline. On May 6, 1988, NMFS announced

its intention to publish a proposed rule designating this population "depleted" under the MMPA (53 Fed. Reg. 16299).

Effect of Incidental Take on OSP

It is unlikely that the level of incidental take of sea lions in commercial trawl fisheries alone has caused the observed declines; however, small local populations may have suffered from the loss of sexually mature females. Additional losses from domestic and foreign fisheries, and direct takes by shooting, may cause a cumulative adverse impact.

Research needs

A detailed list of specific studies needed for northern sea lions is available in NMFS' National Marine Mammal Laboratory 5-year Research Plan and in Hoover (1988).

Major objectives include: (1) Determine and eliminate or mitigate the causes(s) of the population decline; (2) Obtain reliable estimates of the numbers of animals being shot and entangled, the age and sex composition of those killed and seriously injured, and when, where and how this is happening; (3) Assess and monitor population trends; (4) Assess and mitigate indirect and direct effects of fisheries; (5) Identify stocks.

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Northern (North Pacific) fur seal *Callorhinus ursinus*

Stock Definition

The northern fur seal is a monotypic genus and species ranging across the sub-arctic waters of the North Pacific Ocean and portions of the Sea of Japan, and the Okhotsk and Bering Seas. Breeding populations are found on Robben Island in the Okhotsk Sea, several of the Kuril Islands in the western North Pacific Ocean, the Commander and Pribilof Islands in the Bering Sea and San Miguel Island in the eastern North Pacific Ocean. A new colony has recently been established on Bogoslof Island (Lloyd et al. 1981). The general background of history and biology is presented in Scheffer et al. (1984) and York (1987).

Distribution

The general distribution of northern fur seals at sea is described in Kajimura (1984a). Most mature fur seals are on or near their breeding islands from June to November and spend the remaining months at sea. Immature seals may or may not return to their islands of birth each year. Fur seals range across the North Pacific Ocean north of the sub-arctic boundary and are rarely found in water with a surface temperature greater than 15°C. They tend to concentrate along the continental shelf and slope where nutrient-rich waters support a variety of prey species. Some migrate south in the eastern North Pacific Ocean to about lat. 32°N (California-Mexico boundary) and in the western North Pacific Ocean to about lat. 36°N off Honshu Island, Japan. In the Sea of Japan, they range south to about lat. 37°N on the Korean coast. There have been a few sightings of fur seals south of these latitudes. Most male seals remain in the northern portions of their range; however, much of the Okhotsk Sea, about three fourths of the Bering Sea and about half of the Sea of Japan are ice-covered in winter and on occasion the ice remains in the vicinity of the breeding islands into June (Robben Island and rarely St. Paul Island). Based on tag recoveries, seals wintering in the Sea of Japan are considered to be principally of Robben Island origin. Seals wintering in the western North Pacific Ocean are primarily from the Commander and Kuril Islands populations; although some Robben Island and Pribilof Island seals are present. Seals wintering in the eastern North Pacific Ocean are primarily from the Pribilof Islands; although seals from Robben Island and the Commander Islands populations are present.

Based on tag recoveries and sightings, seals from the Pribilof Islands and Commander Islands intermix on their respective home islands more frequently than seals from other breeding islands. Robben Island seals occur more frequently on the Commander Islands than on the Pribilof Islands. On Robben Island, seals from the Commander Islands are the most numerous visitors, although a few

seals from the Pribilof Islands have been recorded. On the Kuril Islands rookeries, seals from the Commander Islands are the most numerous visitors followed by those from Robben Island and the Pribilof Islands. Tagged seals from the Commander Islands have also been noted on Bogoslov Island. At San Miguel Island off California, seals from the Pribilof Islands are most numerous followed by Commander Islands and Robben Island seals. A relatively small number of seals have been tagged at San Miguel Island; most recoveries from this population have been north of Pt. Conception in California with one recovery from the commercial harvest on St. Paul Island.

Older males (10-15 years) winter farther north in the North Pacific Ocean than younger males and females. In the eastern North Pacific Ocean, females and young males appear during their southbound migration along the continental shelf from about lat. 57°N to 46°N in late November and off central California from lat. 40°N to 38°N in late December. During January-April, major concentrations occur from about 49°N to 34°N. Yearlings (pups born the preceding July) appear along the coast from about 57°N to 46°N in January and off California 42°N to 38°N in late February or early March. The spring (northbound) migration in the southern portion of the winter range may begin as early as March. In their northbound migration, some seals follow the continental shelf northward, then westward through the Gulf of Alaska and into the Bering Sea through the eastern Aleutian Island passes. Many seals appear to move in a relatively straight line to their breeding island, in effect, retracing their southbound paths as described below. The older (socially mature) males are usually the first to arrive on the home islands in May and are followed by the older females in late June. Younger males and females continue to arrive, usually in descending order of age. Many of the yearlings and two-year-olds of both sexes do not return, remaining scattered across the sub-arctic waters of the North Pacific Ocean during their first year or two of life.

In their southward migration, seals bound for the eastern North Pacific move through the eastern Aleutian Islands passes and fan out across the eastern North Pacific Ocean to arrive at about the same time along the eastern continental shelf from about Sitka, Alaska (57°N) to the Columbia River (46°N) and a few weeks later off the Farallon Islands (38°N).

Population Estimates

The estimated size of the northern fur seal population was about 1.2 million in 1983. No significant changes have been documented since that time (York and Kozloff 1987) although the recent counts of adult males on the Pribilof Islands and the counts of pups on Robben Island have declined in several more recent years. The population on each island group as estimated for 1979-1983 is as follows (from Report of the North Pacific Fur Seal Commission, Workshop on population trends of northern fur seals: causes and

methodology, March 25-30, 1984, Moscow, USSR): Pribilof Islands (E. Bering Sea) 871,000; Commander Islands (W. Bering Sea) 210,000; Robben Island (Okhotsk Sea) 75,000; Middle Kuril Islands (W. North Pacific) 47,000; San Miguel Island (E. North Pacific) 4,000. The total species population was therefore estimated as 1,207,000.

Incidental Take in Fishery Operations

Fur seals are occasionally taken incidentally in the high-seas gillnet fisheries for salmon and squid. They are also known to be infrequently or rarely taken in longline and trawl fisheries. Jones (1982) summarized information on incidental take of northern fur seals in gillnet fisheries. Based on direct observations of Japanese high seas gillnet fishing operations for salmon, it is estimated that the take of northern fur seals in this fishery is probably less than 200 per year. Insufficient data are available to determine island of origin for the incidentally taken animals. From a sample of 12 animals (all taken west of long. 175°W), one had been tagged at Medny Island, Commander Islands. Seals caught on longline gear were usually hooked in a flipper or, occasionally, in the mouth.

In 1986, a U.S. observer aboard a Japanese squid drift net vessel reported the taking of 14 fur seals during 30 sets. At this time, insufficient data exist on which to base any conclusions regarding the actual level or rate of incidental take in this fishery.

Other Factors Affecting Population

Sources of natural mortality in the form of predation, diseases, starvation, accidents and the effects of weather have all been documented for northern fur seals. Hookworm mortality appears to have a limiting effect and becomes more serious at higher population levels. Prey abundance is expected to be an important factor in determining population levels and trends; but, as reviewed in Kajimura (1984b), commercial fisheries seem not to have significantly influenced the biomass of fur seals' prey. Current levels of body size (or growth) and low pup mortality are inconsistent with the concept that food is more limiting in the current environment of fur seals than earlier (Fowler 1984b).

Discarded fishing debris and other materials have also been identified as a cause of fur seal mortality. Fur seals become entangled in such materials resulting in some observed mortality, both on land and at sea, and a small portion of entangled animals among the seals observed on land. Although it is not known precisely how many fur seals may become entangled and die at sea, there is evidence that such entanglement may be contributing significantly to recent declining trends in the Pribilof Island population (Fowler 1987).

Optimum Sustainable Population (OSP)

The pre-exploitation level of fur seals is unknown. The best estimate is that the Pribilof Island population was between 2-3 million and the Commander Island from 1 to 1.7 million. On the Pribilof Islands by the early 1950s, the herd size was probably approaching the level of 1867 (Alaska purchase). This herd size was probably close to the carrying capacity of the ecosystem at that time. Although females were spared during harvesting from 1917 through 1955, by the early 1940s herd growth had declined from the 8% annual rate observed during 1912-24, the period of rapid population recovery. Starting in 1956 and ending in 1968, a harvest of females from the Pribilof Island population contributed significantly to a decline in the population during that period of time (York and Hartley 1981).

Data for various components of the Pribilof population exist for extended periods of time making possible comparisons of recent levels with historic levels (Lander 1980). Such comparisons indicate that the current levels of that stock are significantly reduced compared to the levels observed in the 1940s and early 1950s after the population had reached its highest levels since the early 1900s. For example, harvest levels in 1983 on St. Paul Island were about 38% of the mean levels for the period between 1940 and 1956. Rookery area currently occupied on St. Paul (as measured in 1985) was less than one third the area estimated for 1948. The estimated numbers of pups born on St. Paul are about 40% of the mean levels estimated for the earlier period. Territorial males with females on St. Paul are about 37% of the levels observed earlier.

Data on pup production on Robben Island and the Commander Islands have been available only since the mid-1950s when the stocks were estimated to be well below the level of maximum sustained yield (MSY) for a harvest of subadult males. Due to harvesting restrictions, the population of the Commander Islands has since increased, while that on Robben Island has decreased. For the Commander Islands, Lander and Kajimura (1982) estimate that MSY for a harvest of subadult males is achieved at a pup production level of 50,000-55,000 per year. Pup production has exceeded this level since the early 1960s.

Ichihara (1972) estimated that MSY for the Robben Island fur seal population would occur when 45,000 pups are born annually. Lander and Kajimura (1982) calculated that MSY for a harvest of subadult males occurs when 50,000 pups are produced annually. Currently pup production is below these levels.

NMFS has designated the Pribilof Island population of northern fur seals as depleted under the MMPA (53 Fed. Reg.17888, May 18, 1988). This action is taken because the reduced numbers in that population are below half of the estimated levels of the 1940s and early 1950s

in comparison to estimated maximum net productivity level (MNPL) of 60% or more of the carrying capacity (c.f. Smith 1973; Fowler 1984a; Fowler 1985). Biological indices (body size, pup survival) used to judge the status of the population relative to its carrying capacity indicate that current population levels are approximately as far below the current carrying capacity as they are below mean population levels of the 1940s and early 1950s (Fowler 1985). This implies that carrying capacity has not changed dramatically since the 1940s and 1950s.

Effect of Incidental Take on OSP

The present level of estimated incidental mortality due to commercial fisheries is small compared to the total population size. If estimates are reliable, this source of mortality probably has negligible effects on population levels. However, because of small sample sizes, especially in the squid gillnet fishery, further research is required to determine whether or not there is a significant effect.

Research Needs

The study of northern fur seals has been the subject of much debate and discussion by a variety of interest groups and scientists. The principle objectives of fur seal research are as follows: (1) Determine and monitor population size and trends and biological characterization essential to the species' survival; (2) Identify the cause(s) of population trends and estimate the degree to which various cause(s) contribute to population changes; (3) Assess the possible adverse effects of man-caused activities and environmental events on fur seal populations and habitats essential to their survival and recovery; and (4) Conduct studies that help provide information for necessary resource management actions.

Following a fur seal research review conducted in 1987, research priorities were identified as:

Population synthesis and analysis of dynamics.

- A review of historic data, a reassessment of previous analysis of population trends, and a synthesis of diverse northern fur seal data sets are essential to guiding future research efforts.

Population assessment and trend analysis.

- The level and any trends in pup production should be determined annually, and total counts of bulls made to determine the size and growth rate of the eastern Pacific population of northern fur seals (St. Paul, St. George, Bogoslof, and the Channel Islands).

Reproduction and mortality

- Since the estimated number of pups has decreased and may still be decreasing, one explanation is reduced recruitment from: 1) a decline in pregnancy rates, 2) increased age at first reproduction, or 3) changes in survivorship of females contributing to a shift in recruitment. Longitudinal records of the presence and reproduction of identified individuals over a number of years are needed to document the natality rate and survivorship.

Feeding ecology

- Current information is inadequate to conclusively determine if reduced food availability near the Pribilof Islands or elsewhere has contributed to recent declines.

Debris entanglement

- Mortality at sea from entanglement in trawl webbing or other debris may be an important factor contributing to the decline. Data on entanglement rates of juvenile males are needed from St. Paul Island to be compared with historic information and to estimate and then compare the survival rates of entangled and non-entangled animals.

Diseases and pathogens

- Further information on the incidence of diseases as causes of death is needed, since diseases are potential contributors to mortality and to population declines.

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Harbor seal *Phoca vitulina* (Pacific)

Stock Definition

The Pacific harbor seal population probably has a single gene pool; however, data needed to determine whether this is a single stock or several distinct stocks are not available. Evidence presented at a hearing on the return of marine mammal management to the State of Alaska in 1976 tended to support the belief that there is only one population stock of the Pacific harbor seal in Alaska. A blood protein analysis on various isolated harbor seal groups indicates that they are a common genetic population.

Boveng (1988) has divided the harbor seal population on the west coast into three stocks: inland waters of Washington (Hood Canal, Puget Sound, and straits of Juan de Fuca), outer coast of Washington and Oregon, and California. In designating these stocks he considered aspects of harbor seal biology as well as management implications. He separated the harbor seals in the inland waters of Washington from coastal Washington and Oregon harbor seals based on Tempte's (1986) description of differences in mean pupping date and Calambokidis et al.'s (1985) documentation of differential concentrations of pollutant loads in seals from inner and outer coastal areas.

Harbor seals on the outer coast of Washington and Oregon are included in a single stock because of studies that document movement between the lower Columbia River for foraging and adjacent bays and estuaries for pupping and molting (Jefferies 1985; Brown 1988). These movement patterns apparently have evolved in response to the seasonal abundance of prey species returning to the Columbia River to spawn.

Boveng (1988) considered harbor seals in California as a separate stock because of the discreteness of survey efforts and isolation of most fishery interactions, particularly mortality in gillnets. Movement of seals between California and Oregon has been reported (Herder 1985; Brown and Mate 1983). However, the rate of exchange is probably small and the fisheries that the seals interact with most often are separated geographically.

The rate of exchange between the Channel Islands in the Southern California Bight and the mainland California Coast needs to be determined. Boveng (1988) discussed the rationale for separating these two groups of animals as "stocks" but did not define them as separate management units.

Distribution

The harbor seal is the predominant nearshore phocid in much of its range. In the eastern North Pacific Ocean, the distribution of the harbor seal in Alaska is continuous from southeastern Alaska to the northwestern limits of their range in the Bering Sea. They occupy virtually all nearshore marine habitats and are seasonally found in many rivers and lakes during the spawning runs of anadromous fishes. Harbor seals are usually considered a nearshore species; however, sightings of animals up to 100 km offshore have been made. They frequently concentrate in the glacial fjords of southeastern Alaska. In the Gulf of Alaska, sectors of abundance include Icy Bay, Cape St. Elias, and Copper River.

Along the southern side of the Kenai Peninsula and around to Kachemak Bay, concentrations occur in Windy Bay, Aialik Bay, Harris Bay, and Nuka Bay. Seals are also abundant throughout most of the Kodiak Island-Afognak Island complex; and major concentrations occur at Tugidak Island off the southern tip of Kodiak and Alitak Bay, on Ugak Island, and around Afognak Island. Concentrations are found along the southside of the Alaska Peninsula at Chirikof Island and in the Shumagin Islands and in the eastern Aleutian Islands. Major concentrations occur on the northern side of the Alaska Peninsula; the two most important areas are Port Heiden and Port Moller.

Local concentrations of seals occur eastward along the northern side of the Alaska Peninsula, the islands of northern Bristol Bay northward to Cape Newenham, with a major concentration occurring during molt in Nanvak Bay. Large scale migrations of harbor seals are not known to occur, although seasonal movements possibly related to heavy ice formation take place in Bristol Bay, Cook Inlet and many fresh water habitats.

The harbor seal is abundant throughout the coastal and estuarine areas of Washington and Oregon. In California, harbor seals are abundant along the entire coast although significant numbers have not been recorded south of San Clemente Island. Jefferies (1985), Brown (1988), and Hanan et al. (1985, 1986a, 1986b, 1987) document the location and number of seals using hauling out areas along the west coast. They also document which of these hauling out areas are used as rookeries.

Population Estimates

Estimating abundance of this species in Alaska has been difficult; however, from past harvesting records and aerial surveys in selected areas, particularly Kodiak Island and the northern side of the Alaska Peninsula, the Alaska Department of Fish and Game (ADF&G) estimated that the total population is 270,000 seals.

As harbor seal interactions with commercial and recreational fisheries began increasing on the west coast (WA, OR and CA) in the early 1980s, several studies were begun on harbor seal populations and trends in abundance (Miller et al. 1983a,b; Hanan et al. 1985; Jefferies 1985; and Brown 1988). These studies are generally based on aerial surveys conducted at times when maximum numbers of animals are expected to be hauled out.

The Washington Department of Wildlife surveyed the Straits of Juan de Fuca, San Juan Islands, and northern Puget Sound in August 1984. They counted 4,522 harbor seals (Jeffries pers. comm. cited in Boveng 1988). Calambokidis et al. (1985) counted 719 seals in southern Puget sound and 821 in Hood Canal on 13 September 1984. Assuming no movement between areas, combining these counts produces a minimum population estimate for the Washington inland waters stock of 6,062 harbor seals.

The Washington-Oregon stock consists of animals which use estuarine and rocky coastal habitats. Brown (1988) reported aerial survey results for the Oregon Coast for the years 1977-84. His highest count (4,418 harbor seals), including 584 pups, was obtained in June 1985. Harbor seal censuses in Washington have concentrated surveys during pupping season in estuaries where most pups are born. Jeffries (1985) reported a total count of 5,869 seals in Willapa Bay and Grays Harbor in 1982. Jeffries (pers. comm. cited in Boveng 1988) counted 2,103 seals on the outer coast of the Olympic Peninsula in September 1978. Boveng (1988) combined these counts to produce a minimum population estimate for the Washington-Oregon stock of 12,390 harbor seals.

A series of harbor seal surveys has been conducted along the California mainland coast (Miller et al. 1983a,b; Hanan et al. 1985, 1986a, 1986b, 1987, and in press). These surveys have documented the continued recovery of the California harbor seal population in recent years. The 1987 mainland count was 15,300 seals, and the 1987 count for the Channel Islands was 4,322 seals (Hanan et al. in press). Combining these counts produces a minimum population estimate for the California stock of 19,622 seals. Combining counts from WA inland waters, WA-OR stock, and CA stock produces a minimum west coast population estimate of 38,074 harbor seals.

A number of studies (e.g., Pitcher and McAllister 1981; Stewart and Yochem 1983; Herder 1985; Allen et al. 1986; Harvey 1987) have been conducted to determine the proportion of seals hauled out and available for counting, so that counts on land could be expanded to total population estimates. Due to various constraints discussed in Boveng (1988), none of the studies defines the proportion of the population that might be hauled out during a regional census; however, the studies suggest that the proportion is probably 50 to 70%. In his analysis of population status, Boveng (1988) uses the counts as minimum population estimates and expands them by a factor

of 2 for a maximum population estimate. He uses a correction factor of 1.4 to give a midpoint population estimate. The total population of harbor seals on the west coast (updated to include censuses not available to Boveng 1988) is likely to be in the range of 38,074 to 76,148. The midpoint estimate is 53,303 harbor seals.

Incidental Take in Fishery Operations

The estimated take of harbor seals incidental to commercial fisheries off Alaska was estimated to be 1,440 in domestic and 289 in foreign fisheries (NMFS 1978). More recently an estimate of 2,800 animals is provided by Brooks (1979). The harbor seal range rarely overlaps with the location of the foreign fisheries and incidental take is correspondingly low (verified by recent information from the U.S. observer program aboard foreign fishing vessels). The incidental take of harbor seals in domestic fisheries of Alaska is limited almost entirely to the gillnet fishery for salmon. Harbor seals remove or mutilate salmon which are caught in gillnets and in which they occasionally become entangled and drown. Most entangled seals that do not drown are killed (usually by shooting) by fishermen in order to remove them from the net, although a few are released alive. Harbor seals seen around gillnets are often shot at by fishermen and occasionally killed.

Jeffries (pers. comm. cited in Boveng 1988) estimated that 50 to 100 harbor seals are taken incidentally in Puget Sound gillnet fisheries each year. Geiger (1985) estimated 193, 334, and 210 harbor seals were killed in Columbia River gillnets in 1980, 1981, and 1982, respectively. Brown (pers. comm. cited in Boveng 1988) and Jeffries (pers. comm. cited in Boveng 1988) suggest that the incidental mortality in the Columbia River has probably increased due to increased fishing effort associated with the rebuilding of the Columbia River fisheries. Total annual mortality in the Columbia River is likely to be between 350 and 400 seals. Geiger (1985) reported takes in Willapa Bay and Grays Harbor of 142 seals in 1980. Assuming mortality rates in those areas have remained stable, the estimated annual incidental mortality of Washington-Oregon harbor seals is about 400-500 seals.

The California Department of Fish and Game conducts several gillnet monitoring programs (Collins et al. 1984, 1985, 1986; Diamond et al. 1986a, 1986b; Wild 1986a, 1986b; Haugen 1986). Observed mortality is extrapolated over an estimate of total fishing effort to produce an estimate of annual mortality incidental to gillnet fisheries. Hanan et al. (in press) has estimated total harbor seal mortality in California gillnet fisheries as 833 seals in the 1983-84 fishing season; 1,138 seals in the 1984-85 fishing season; and 1,911 in the 1985-86 fishing season. The increasing trend in mortality rates is likely to be a result of increases in fishing effort and increases in the abundance of harbor seals.

In addition to the levels of take that have been enumerated, harbor seals are subject to other types of unquantified mortality. For example, unknown numbers are shot to protect fishing gear and catch from depredation, unknown numbers are shot illegally (Miller et al. 1983a), and unknown numbers are tangled and die in debris, some of which originates from the fishing industry (Stewart and Yochem 1985).

Optimum Sustainable Population

In Alaska, prior to the MMPA, harbor seals were subjected to substantial hunting pressure in areas where they were taken for subsistence, bounties, and pelts. The harvest of harbor seals in Alaska peaked in 1965 at 50,000 seals before falling to 9,000-11,000 by 1972. This harvest was closely studied and, because of its localized nature, probably had little direct effect upon the statewide harbor seal population. Seals from adjacent unexploited areas may have repopulated locally depressed areas, as happened in the Copper River after a predator control program designed to reduce fisherman/harbor seal conflicts ceased in 1962.

In Alaska, harbor seal numbers are declining in parts of the Gulf of Alaska and north side of the Alaska Peninsula (Pitcher 1986). Between 1976 and 1982, maximum counts of harbor seals on Tugidak Island, the largest rookery in U.S. waters located near Kodiak Island, declined by 75% (Hoover 1988). Counts of harbor seals conducted in 1985 along the north coast of the Alaska Peninsula indicate that the population may have declined 3.5% annually since 1976 (Pitcher 1986).

In 1978, NMFS agreed with the ADF&G that the harbor seal population in Alaska was above the lower level of its range of OSP sizes (NMFS 1978). However, the magnitude and geographic extent of recent population declines will have to be evaluated before the current status of Alaska harbor seals relative to OSP levels can be determined.

Boveng (1988) conducted a dynamic response analysis (DeMaster et al. 1982; Boveng et al. in press; Goodman in press) of the California harbor seal census data to determine the status of the California stock relative to its maximum net productivity level (MNPL, the lower bound of OSP). The analysis indicated that the population was probably below its MNPL, but the data were too uncertain to make a definitive statement. More reliable information on incidental mortality and a longer series of censuses is need to support a definitive analysis. Nevertheless, his analysis leaves the impression that the California harbor seal stock is in a recovery phase and has not yet reached an optimum level.

Quantitative data on stock sizes and trends, and on incidental mortality for the Washington-Oregon and Washington inland waters stocks indicate that the populations are growing at 6% or more annually, while sustaining incidental mortality in the fisheries of approximately 2% of the minimum estimated population levels. A determination of status relative to OSP is not presently possible. However, the apparent increases in population size, and increasing interactions with commercial and recreational fisheries, indicate that the status of these two stocks may be similar to the California stock, i.e., below MNPL but increasing.

Effect of Incidental Take on OSP

The harbor seal population in Alaska was determined to be within OSP levels in 1978. The previously cited estimates for incidental take (1,440 and 2,800) are 0.5 and 1% of the total 1978 population estimate (270,000). If the potential net productivity for phocid seals is 4-8%, it does not appear that incidental take at this level could significantly affect population size and its relationship to OSP. However, recent declines may have altered this relationship.

The recent increase in indices of abundance for the Washington inland waters stock observed by Calambokidis et al. (1985) and Jeffries (pers. comm. cited in Boveng 1988) suggest that the current level of take here appears to have a negligible impact on the stock (Boveng 1988).

The Washington-Oregon stock does not appear to have been significantly affected by the level of mortality incidental to commercial fisheries (Boveng 1988). Harbor seals in Oregon appear to have increased at a rate of about 6% a year between 1977 and 1985 (Brown 1988), and harbor seals on the outer coast of Washington are probably increasing at least as fast as the Oregon populations. This increase in the Washington-Oregon Stock is occurring despite an incidental mortality of about 400-500 harbor seals a year.

Likewise there is no indication that incidental mortality has affected the California stock adversely. The index of abundance continues to increase despite the level of mortality. The increasing rate of incidental mortality is cause for concern. Mortality in the 1985-86 fishing season exceeds 9% of the 1985 midpoint population estimate. Wild (1985, 1986) reported that most of the harbor seals taken in central California gillnets were small, probably young of the year. Boveng (1988) estimated that if the 1985-86 kill were composed entirely of pups it could eliminate 40% of that year's cohort. Predicting the impact of that level of mortality on the population would require better knowledge of natural pup survival rates and knowledge about the timing of the incidental take relative to periods of high natural pup mortality.

Research Needs

Additional information necessary for management of harbor seals includes:

Full assessment of mortality rates due to incidental take in commercial fisheries.

Assess the magnitude and geographic extent of apparent population declines near Kodiak Island and in Bristol Bay, and ascertain their causes.

Regular systematic censuses such as are conducted in California and Oregon.

Tagging or marking projects to facilitate development of a correction factor for estimating total population size from counts and to address the question of stock structure.

Other methods of addressing the question of stock definition should be investigated. For example, analysis of mitochondrial DNA or DNA finger printing.

Development of life history information: birth rates, natural mortality rates, longevity, age at first reproduction. This information is necessary for determining maximum allowable take and monitoring the status of the populations.

Quantification of the economic loss that harbor seals cause commercial fisheries and assessment of the effect of the harbor seal population on natural and hatchery produced fish stocks, in particular salmonids.

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Harbor Seal *Phoca vitulina* concolor (Atlantic)

Stock Definition

One species of harbor seal is found in the western North Atlantic from the eastern Canadian Arctic islands and Greenland south to New England and New York. No information on stock differentiation is available in the western North Atlantic, although it is thought that harbor seals found along the eastern U.S. and Canadian coast represent one population (M. Payne pers. comm.).

Distribution

Harbor seals are year-round inhabitants of the coastal waters of eastern Canada and Maine (Katona et al. 1983), and occur seasonally in southern New England and New York from September through late May (Schneider and Payne 1983). In addition, scattered sightings have been recorded as far south as Georgia (NMFS unpubl. data). A northward movement from southern New England to Maine occurs prior to the pupping season which takes place from mid-May through June along the Maine coast (Wilson, 1978). No pupping areas have been identified in southern New England (Payne and Schneider 1984). The overall geographic range throughout coastal New England has not changed significantly during the last century (Payne and Selzer in press).

Population Estimates

Since protection was given to harbor seals under the Marine Mammal Protection Act in 1972, the number of seals along the New England coast has more than doubled (Payne and Schneider 1984). The total number of harbor seals in New England waters is estimated to be between 10,500 and 15,000 seals (Gilbert and Stein 1981; Katona et al. 1983). Aerial surveys conducted along the coasts of New Hampshire and Massachusetts by the Manomet Bird Observatory since 1983 suggest an increasing abundance of seals (Payne and Selzer in press). Aerial surveys conducted along the Maine coast in 1986/87 by the University of Maine also indicated that the harbor seal population was still increasing, but at a decreasing rate (Gilbert and Wynne 1988).

Incidental Take in Fishery Operations

Incidental takes of harbor seals have been recorded in the groundfish gillnet, herring purse seine, halibut tub trawl and lobster fisheries (Gilbert and Wynne 1985; Gilbert and Wynne 1988). A study conducted by the University of Maine reported a combined average of 22 seals entangled annually by 17 groundfish gillnetters off the coast of Maine (Gilbert and Wynne 1988). All seals were young of the year and were caught from late June through August, and in early October. Interviews with a limited number of mackerel

gillnetters indicated only one harbor seal entanglement and a negligible loss of fish to seals. Capture of seals appears to take place as both surface and bottom gillnets are set. Net damage and fish robbing were not reported to be a major economic concern to gillnetters interviewed (Gilbert and Wynne 1988).

Herring purse seiners reported accidentally entrapping seals off the mid-coast of Maine. They indicated that the seals were rarely drowned before the seine was emptied (Gilbert and Wynne 1985). Capture of seals in the halibut tub trawls are rare. One trawler indicated that he took 1 or 2 seals a year. These seals were all hooked through the skin and released alive, indicating they were snagged as they followed baited hooks. Infrequent reports suggest seals may rob bait off longlines, although this loss is considered negligible (Gilbert and Wynne 1985).

Seals were rarely reported caught in lobster traps in the inshore waters off Maine. Captures of approximately 2 seal pups per port per year were recorded by mid-coastal lobstermen off Maine (Gilbert and Wynne 1985). Seals have been reported to rob bait from inshore lobster traps especially in the spring when fresh bait is used. These incidents may involve only a few individual animals. Lobstermen claim that seals consume shedding lobsters. They have noticed an increase in numbers of seals while they experienced a decrease in the lobster harvest. However, this conflict is difficult to define as there are several environmental factors that also may be correlated with this event.

Optimum Sustainable Population (OSP)

No OSP estimate has been developed for this population.

Effect of Incidental Take on OSP

Although the available information suggests that levels of take are small relative to population size, the precise effect of incidental take on harbor seals in the western North Atlantic cannot be determined due to inadequate population and incidental take data. Research on the incidental take of harbor seals in fishing operations off the coast of Maine was conducted by interviewing a limited portion of the fishing community. The report of that work warns against extrapolating these data to the entire fishery, since the rate of incidental takes is not constant along the entire coast of Maine. However, the capability of the population to withstand significant losses can be demonstrated by the fact that a series of aerial censuses showed an increasing population over the period when more than 350 seals were found dead in the Cape Cod area from an influenza outbreak. The recent increases in seal abundance throughout southern New England may increase conflicts between seals and the fishing industry.

Research Needs

Several additional research activities need to be undertaken to evaluate the status of the harbor seal populations in this region and the effects of the current levels of incidental take.

Monitor population size and determine rates of increase through periodic systematic census of harbor seals.

Determine the extent of indirect conflicts between the fishery industry and the harbor seal population by monitoring temporal and spatial variation in food habits, and the degree of overlap in human/seal foraging patterns.

Determine the size, sex structure, age, and reproductive data through necropsy of animals taken in the fishery.

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Northern elephant seal *Mirounga angustirostris*

Stock Definition

The northern elephant seal's recovery from near extinction is well documented (Bartholomew 1967; Le Boeuf 1977). The extant population may have descended from a small group of about 100 animals located on Isla de Guadalupe, Mexico, near the turn of the century (Bartholomew and Hubbs 1960). As a result of the bottleneck through which the population passed it may have virtually no heterogeneity in the gene pool. Bonnell and Selander (1974) found no polymorphism in 21 blood proteins at 24 different loci in a sample of 124 elephant seals from five different colonies. Le Boeuf and Bonnell (1980) reviewed the dynamics of the recovery including information on the rates of immigration to new colonies. Based on the history of the population, the homozygosity of the population, and the high rates of immigration, it is evident that the northern elephant seal population comprises a single gene pool.

Boveng (1988) included only the U.S. rookeries in his assessment of population status because data on population growth at Mexican rookeries are insufficient to conduct an assessment. Managing the U.S. population as a separate stock would not be inconsistent with the definition of stock used by Larkin (1972) and MacCall (1984): a collection of animals that can be sensibly managed as a single unit.

Distribution

This species originally occupied rookeries and hauling grounds on the mainland and islands from Cabo San Lazaro, Baja California, Mexico, northward to Pt. Reyes, California in the eastern North Pacific Ocean. Nonbreeding animals range at least as far north as the Gulf of Alaska, and are regular seasonal visitors off Washington and Oregon. Sightings of single animals far from their normal range have been made recently at Midway Island and in the eastern Aleutian Island. The species now commonly breeds on Isla San Benito, Isla Los Coronados, Isla Natividad, Isla Guadalupe, and Isla San Cedros off Mexico, and San Miguel Island, Santa Barbara Island, San Nicolas Island, Año Nuevo Island, Pt. Año Nuevo, on the mainland opposite Año Nuevo Island, South Farallon Islands and Point Reyes Peninsula off the United States. Most of the adult animals exhibit strong site fidelity (Le Boeuf and Bonnell 1980).

Population Estimates

Commercial harvesting almost extirpated the northern elephant seal population. By 1890, the population was reduced to less than 100 animals found only on Isla Guadalupe (Townsend 1899). This number increased to an estimated 15,000 animals by 1960 (Bartholomew

1967). LeBouef and Bonnell (1980) estimated a total population of about 60,000 in 1977 (42% in the U.S.). Cooper and Stewart (1983) reported a combined Mexico-U.S. population growth rate of 8.3% for the period 1965 to 1977. If this rate continued the population would have grown by 1988 to about 144,000 (about 60,000 in the U.S.). This species has reoccupied most or all of its historic rookeries and hauling grounds. Le Boeuf and Bonnell (1980) reported that, in 1977, only Islas Guadalupe and San Benitos had stable populations and all the other colonies were continuing to increase. They reported that rookery space seemed to be the major factor limiting population growth. If space has become limiting on other Mexican islands, the assumption of continued high growth may not be valid.

As with other species of pinnipeds, there is no time during the year when the entire population is hauled out and available for counting. The only age class which lends itself to a nearly complete census is the cohort of pups born during January and February. Boveng (1988) expanded the 1986 U.S. pup counts to a population estimate of 50,800 elephant seals in U.S. waters. He also calculated a population growth rate for U.S rookeries of 8.75% for the period 1980 through 1986. Applying this to his 1986 population estimate produces a 1988 estimate of about 60,000 elephant seals in the U.S. population.

Incidental Take in Fishery Operations

Miller et al. (1983) estimated that about 25 elephant seals were killed by entanglement in gillnets each year during their 1979 - 1980 survey of marine mammal/fishery interactions. Other gillnet monitoring programs (Wild 1986a,b; Collins et al. 1986; Collins et al. 1985; Collins et al. 1984; Diamond et al. 1987; Diamond et al. 1986a,b) document that elephant seal mortality is rare.

There is apparently some incidental mortality in offshore trawl and longline fisheries. Condit and Le Boeuf (1984) found reports of 9 elephant seals caught in fishing gear off the coasts of California, Oregon, and Washington. Elephant seals seem to be widely dispersed at sea because offshore sightings are usually of solitary animals (Antonelis and Fiscus 1980). Therefore, mortality in pelagic fisheries is probably rare.

Studies of elephant seal diving patterns (Le Boeuf et al. 1985, Le Boeuf et al. 1986) show that they tend to forage in deep offshore waters and are probably spatially separated from most commercial fishing operations. These results tend to verify the low rate of interaction between elephant seals and commercial fisheries.

Optimum Sustainable Population (OSP)

Boveng (1988) conducted a dynamic response analysis (DeMaster et al. 1982; Goodman 1988) of pup counts through 1986 and concluded that the U.S. elephant seal stock was near its maximum productivity level (MNPL), but that pup count data alone were not sufficient to assess whether the population was approaching MNPL from below or departing higher into optimum levels.

Recent observations of new elephant seal breeding sites (e.g. Le Boeuf and Panken 1977; Bonnell et al. 1983; Allen et al. 1986; Stewart and Yochem 1986), particularly those on mainland beaches, have led to speculation that the population is larger than it was prior to commercial exploitation. Le Boeuf and Panken (1977) hypothesize that mainland rookery sites were not available because of the presence of large terrestrial predators, e.g., wolves and grizzly bears. If this is the case, current carrying capacity of the environment for elephant seals may be larger than it was historically. Establishment of breeding colonies on the mainland may affect existing biological communities in these areas and increase the opportunity for humans to come into contact with and be injured by elephant seals.

Effect of Incidental Take on OSP

Considering the size of the population, the low rate of interaction with fisheries, and the documented high rate of population growth, it is probable that incidental mortality has no significant impact on the population.

Research Needs

The influence of immigration from Mexican elephant seal colonies on the per capita production needs further study to augment the dynamic response analysis of population status. Specifically, tagging studies should be undertaken cooperatively by U.S. and Mexican researchers with the objective of determining rates of exchange based on effort corrected tag and resight data. In addition, more data are needed to determine the actual mortality rate of elephant seals in commercial fisheries.

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Spotted Seal *Phoca largha*

Stock Definition

Spotted seals (Phoca largha) are distributed along the continental shelf of the Beaufort, Chukchi, Bering, and Okhotsk Seas south to the northern Yellow Sea and western Sea of Japan (Shaughnessy and Fay 1977). Eight distinct breeding areas have been identified (Fedoseev and Schmakova 1976; Gol'tsev et al., 1975; Shaughnessy and Fay 1977). Five of these are in the Okhotsk and Japan Seas; and the following three are in the Bering Sea: a) Southeastern - Bristol Bay to Pribilof Islands; b) Northwestern - Navarin Basin to Gulf of Anadyr; c) Southwestern - eastern Kamchatka Peninsula from Karaginskii Bay to Olyutorski Gulf.

There is little morphological difference between animals from these areas, indicating that they have been separated only a short time or that there is more interchange than is apparent from available information (Shaughnessy and Fay 1977).
Spotted seals are closely related to north Pacific harbor seals (Phoca vitulina). These two species have similar physical appearance and overlap in range. They are distinguishable based on behavior (e.g., spotted seals breed earlier and are less social during the breeding season), ecology (e.g., only spotted seals are associated with pack ice), and morphology (e.g., skull and hyoid shape and size; Shaughnessy and Fay 1977). However, protein analysis was unable to distinguish between the two species (Shaughnessy 1975).

Distribution

Spotted seals are usually associated with the pack ice edge in winter and spring, and with terrestrial haul-outs in summer and fall. Pupping occurs in the Bering Sea from late March through mid May (Burns et al. 1972; Tikhomirov 1966) at ice fronts. Mating occurs at the time pups are weaned, about four to six weeks postpartum. During this period, adults are seen on floe ice as female-pup, male-female, or male-female-pup triads. Subadults and nonbreeding animals are generally found in larger groups. At least in the southeastern Bering Sea, herds of seals are found in close proximity to walleye pollock (Theragra chalcogramma) concentrations.

Molting occurs during late spring. Loose groups of up to 200 animals can be found associated with ice remnants, although some seals also molt on land on the eastern Bering Sea coast. This allows these seals to take advantage of spring migrations of herring (Clupea harengus; Burns et al. 1981). Animals move northward and shoreward to the Alaskan and Siberian coasts as ice degrades and recedes. On the pack ice in late winter and spring, spotted seal densities are greatest near the ice front in

southeastern Bering Sea, and Bristol Bay with smaller concentrations along the Soviet coast (Braham et al. 1984). Seals are found during summer along the Alaska coast from Bristol Bay north to the Chukchi with some animals ranging into the Beaufort and East Siberian Seas by August (Shaughnessy and Fay 1977). Lagoons, estuaries, mainland beaches, offshore islands, and pack ice near land are used as haul-outs.

Major haul-outs exist at Bristol Bay (sometimes associated with harbor seals), St. Matthew, Hall, Besboro, and St. Lawrence Islands, Norton and Kotzebue Sounds, Cape Woolley, Port Clarence, Kasegaluk Lagoon, and east of Akoliakatat Pass (Frost et al. 1983a,b). Seal distribution is associated with large concentrations of fish prey (e.g., herring and capelin, Mallotus villosus). Spotted seals move south from their northern range during the fall. Numbers increase along the Bering Sea coast during September to November. By winter, they are again at the ice front's edge.

Population Estimates

Alaska Department of Fish and Game estimated in 1973 that the Bering Sea's spotted seal population was a minimum of 200,000 to 250,000 seals (Burns 1973). This was based on "field observations and relative abundance in comparison with other species" (Burns 1973, p.14). A more recent estimate is not available.

Incidental Take in Fishery Operations

Based on the spotted seal's diet, utilization of the Bering Sea for feeding, foraging strategy, and population distribution, they are likely to interact directly with both the commercial groundfish and herring fisheries (Lowry 1984). U.S. fishery observers on foreign independent fishing vessels and joint venture mother ships recorded the number of marine mammals caught in ground fisheries from 1978 to the present (Loughlin et al. 1983; NMFS unpubl. data). Between 1978 and 1986 at least 2 and perhaps as many as 22 spotted seals were observed to be caught and all died. Uncertainties in this estimate are due to potential misidentification of seals. Twenty seals were caught in areas inhabited by spotted seals and harbor seals but were identified by observers as harbor seals (or in one case as a spotted seal). Another 12 seals caught were definitely harbor seals since they were caught in areas populated only by harbor seals. The number of seals caught increased during this period (from one seal in 1978-80 to six seals in 1986). This apparent increase in incidental take could be due to increased observer coverage (10% in 1978-80 to almost 100% by 1986) or a change in the area fished.

Spotted seals taken incidental to domestic groundfish, herring, and salmon fisheries are usually unreported. Commercial fishermen may, on occasion, deliberately kill seals because of their potential

destruction of fishing gear (especially gillnets), damage of fish in nets, and competition for fish. No data are available to assess this taking. Finally, as with northern fur seals (Callorhinus ursinus; Fowler 1987), some spotted seals may become entangled in discarded fishing gear and other marine debris, and subsequently die. The magnitude of spotted seal mortality is unknown. However, other phocid seals such as harbor seals, elephant seals (Mirounga angustirostris), and Hawaiian monk seals (Monachus schauinslandi) have been observed to become entangled at rates comparable to otariids (Henderson 1985; Stewart and Yochem 1985).

Optimum Sustainable Population (OSP)

The Bering Sea spotted seal population has been assumed to be stable (Burns 1973; USDC 1979). However, without recent estimates of abundance or vital population statistics for the Bering Sea population, there is no empirical evidence to suggest the population is above, at, or below OSP.

Effect of Incidental Take on OSP

Gross annual pup production for Bering Sea spotted seals was estimated at 20-25%, based on data collected from the Okhotsk Sea population (Lowry 1985; Popov 1976). Mortality during the first year could be as high as 45% but then may decline to 8% (Popov 1976). As a result, adult recruitment may be 9 to 11%.
With this level of recruitment, an incidental take by commercial trawl fisheries of 22 seals over a 9 year period (less than 0.01% of the adult and juvenile population) would have a negligible impact on the population. The effects of the commercial harvest of spotted seals, takes (both incidental and intentional) by domestic fisheries, and competition between seals and fisheries for prey have a potentially greater impact.

Soviet commercial sealing and Alaskan Eskimo subsistence harvests have in the past taken an average of 6,000 animals a year in the Bering Sea or about 3% of the juvenile and adult population. The Soviets have a limit for the Bering Sea of 5% of the total population of spotted seals per year or around 8,000 seals (Popov 1976); however, between 1969 and 1983 they harvested only about 3,600 animals per year (Mineev 1981, 1984). Alaska subsistence hunters took nearly 2,400 seals per year between 1966 and 1976 (Lowry 1985). Takes for both groups appear to have declined in recent years (Iya pers. comm.; Mineev 1981, 1984). Data are not available to assess the impact of taking by domestic fisheries.

Limited data on the food habits of Bering Sea spotted seals indicate that walleye pollock and herring are major prey items (Bukhtiyarov et al. 1984; Lowry and Frost 1981). Both prey species support important commercial fisheries, and abundance of both species has varied significantly in recent years (Bakkala et al. 1987; Fredin 1985). The significance of competition for food

between seals and fisheries is difficult to assess, particularly because basic biological data are lacking for the spotted seal. However, the possibility of negative impacts from competition with fisheries cannot be disregarded, particularly since other Bering Sea pinniped populations which feed on pollock and herring are declining (Merrick et al. 1987).

Research Needs

Assess and monitor population status
1) Design and conduct regular surveys of abundance
2) Regularly collect data on vital parameters (e.g., reproductive rates, age distribution) and on population condition indices (e.g., pups weights).

Determine population discreteness by mDNA analysis, tagging, and radio tracking.

Monitor Alaskan and Soviet harvests.

Assess mortality due to incidental and intentional takes in domestic fisheries.

Determine food habits, particularly during winter a period for which little is known.

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Harbor porpoise *Phocoena* (Pacific)

Stock Definition

Yurick (1977) suggests the existence of two populations in the North Pacific Ocean and identifies several factors that may be used to distinguish subpopulations. Gaskin (1984) recognized three subpopulations in the eastern North Pacific: the Bering Sea, the Sea of Okhotsk, and the Gulf of Alaska to Los Angeles Harbor. He further divided the Gulf of Alaska to Los Angeles Harbor subpopulation into three subdivisions: (1) in the Gulf of Alaska from Kodiak Island to Prince of Wales Island; (2) along the coast of British Columbia and the sheltered coast of Washington east of Cape Flattery; and (3) from Cape Flattery Washington to the Los Angeles Harbor (west coast).

Calambokidis (1986) conducted a study of chlorinated hydrocarbon levels in tissues of harbor porpoise as a means of measuring movement patterns and to provide insight into the stock structure of the west coast subdivision. He analyzed samples from 36 harbor porpoise throughout the range of this population and found significant differences in pollutant loads by state. He also found significant differences in harbor porpoise from three areas in California, Morro Bay, Monterey Bay, and the Gulf of the Farallones. He concluded that analysis of pollutant loads appeared promising for examining geographic interchange of animals, but drew no conclusions regarding distinctness of harbor porpoise groups.

Distribution

The harbor porpoise is basically an inshore species, frequenting coastal waters and the mouths of large rivers, harbors, and bays, sometimes ascending freshwater streams. The results of vessel surveys conducted by NMFS in 1984 and 1985 (Barlow 1987a) indicate that more survey work is needed to define the offshore limit of the harbor porpoise range.

In the eastern North Pacific Ocean, the species' range is usually described as from northern Alaska to Point Conception, California, although records of harbor porpoise from Los Angeles Harbor exist. Harbor porpoise are common in Alaskan waters north to Bering Strait with a few records from the Chukchi and Beaufort sea coasts. Barlow (1987a) identified several areas of relatively high harbor porpoise density along the west coast during surveys conducted in September of 1984 and September of 1985. These were the coasts of Washington and Northern Oregon, the California coast between Cape Mendocino and Point Reyes, and Monterey Bay. He found no evidence of discontinuities between these areas of high density. He also found a marked seasonal change in abundance of porpoise in these areas. Very few porpoise were seen during a winter survey conducted in January and February 1985. Barlow postulated that the

apparent change in abundance could have been caused by a shift in distribution to deeper offshore waters during the winter. The seasonal change in abundance was also observed by Dohl et al. (1983).

Population Estimates

Based on the west coast harbor porpoise surveys, Barlow (1987) estimated that there were 49,852 harbor porpoise between Cape Flattery, Washington, and Point Conception, California. He could not produce an estimate of the number of porpoise in California waters because the surveys did not contain a stratum bound by the California/Oregon border. He did estimate that 11,457 porpoise occur between Cape Mendocino (150 Km south of the California/Oregon border) and Point Conception, which will suffice for a California-wide estimate of abundance. He also estimated that about 1,854 porpoise occur in the area between the Russian River mouth and Point Conception. This is the area in which the California set net fishery for halibut operates and interacts with porpoise.

Estimates for coastal Oregon and Washington waters are approximately 35,000 animals (Barlow 1987). There are no statewide estimates of harbor porpoise in Alaska. Hall and Johnson (1978) estimated a seasonal peak of over 500 animals in Prince William Sound. This species is sighted frequently in Alaskan coastal waters north of Bristol Bay and in the Aleutian Islands. Hanna (1923) observed a stranding of 13 animals at St. George Island, Pribilof Islands, on February 2, 1917 when drift ice trapped the animals in Village Cove and pushed them ashore; and there are additional stranding records of dead animals through the early 1970's. Fiscus et al. (1977) mentioned that a 1972 estimate of 1,000 harbor porpoise in the Gulf of Alaska seems small considering the number of sighting records accumulated between 1958 and 1976 in this region. Leatherwood et al. (1986) estimated densities of harbor porpoise of 13 animals per 1000 nmi^2 in the eastern Bering Sea. They also report an apparent absence of harbor porpoise from the eastern Bering Sea during winter months.

Incidental Take in Fishery Operations

The California Department of Fish and Game (CDF&G) maintains observation programs to collect information on the number of birds, mammals, and non-target fish species that are taken in set net fisheries (Wild 1986a, 1986b). The CDF&G also monitors the amount of effort expended in the set net fisheries. Total mortality has been estimated by extrapolating observed mortality rate over the estimated fishing effort. Mortality estimates are available for the following three fishing seasons (California's fishing season runs from April 1 to March 31): 1983/84, 303 +/- 190 porpoise (Diamond and Hanan 1986); 1984/85, 226 +/- 56 porpoise (Hanan et al. 1986); and 1985/86, 226 +/- 53 (Diamond and Scholl 1987).

Set netting effort in the Gulf of the Farallones has apparently declined as a result of restrictions implemented by the State of California in April 1987; a concomitant decline in harbor porpoise mortality is expected.

Although there are records of dead harbor porpoises recovered from gillnets in Washington waters, no estimate of annual take is available for that area. Matkin and Fay (1979) estimated that as many as 58 were killed in the Prince William Sound-Copper River fisheries in 1978, but that there were no takes of harbor porpoise in fisheries in other areas of the Sound. No other data are available for Alaska.

Optimum Sustainable Population (OSP)

Barlow (1987b) conducted an assessment of the status of the west coast harbor porpoise population using a population back projection model. This method compares a current population estimate with a population estimate back calculated to a time when the population was assumed to have been at carrying capacity. NMFS used this assessment technique in determining the status of dolphin stocks taken incidental to yellowfin tuna purse seining in the eastern tropical Pacific Ocean. In that instance, NMFS defined maximum net productivity level (MNPL, the lower bound of OSP) as 60% of the pre-exploitation population size (assumed to equate to carrying capacity, NMFS 1980).

Barlow (1987b) considered a range of values for MNPL, maximum net recruitment rate, and current population size in his assessment. He also considered two stock structures, a west coast stock and a stock defined by the area in which the California set net fishery for halibut operates. In both cases he assumed no recruitment to the stock by immigration and that the stock was at carrying capacity in 1969. All combinations of parameters for a west coast stock were above 91% of the 1969 level or higher. The assessment based on median values for population size, MNPL, and maximum net recruitment rate placed the current population at 98% of the 1969 level. Although no definitive evidence is available to delineate stock structure, Barlow favored the stock delineated by the geographic range in which the fishery occurs because it is the more conservative. Treating the population in the area defined by the distribution of the fishery yields an assessment of population size between 29% and 81% of the level it was at in 1969. Most of the combinations of parameters tested resulted in current populations being below the MNPL (i.e., depleted).

Managing harbor porpoise on the west coast as a single stock may result in localized depletions where the range of the porpoise overlaps with the distribution of certain fisheries, but the other extreme, defining stocks by the distribution of fisheries that take porpoise is likely to lead to unfair restrictions of those fisheries. An approach consistent with the goals of the MMPA would

be to manage harbor porpoise as a single stock with safeguards to protect against localized depletions.

Barlow (1987b) cites the lower densities he observed south of point Reyes, California (the northern limit for legally setting gillnets prior to enactment of more restrictive regulations in 1987) as an indication of local depletion and justification for considering harbor porpoise south of Point Reyes as a separate stock. However, Dohl et al. (1983) also reported lower densities in the southern portion of the Range. Since Dohl et al.'s observations cover years preceding and coincident with the substantial increase in set netting it is possible that there are other explanations for the lower density.

Mayr's (1963) evolutionary perception of peripheral populations and the concept of peripheral populations in MacCall's (1983) basic model of habitat selection provide equally plausible explanations for lower densities at the southern limit of the harbor porpoise range. Mayr (1963) describes peripheral populations as those that are subjected to severe selection pressures because they are at the limits of what is habitable habitat for a particular species. This results in lower survival rates and lower densities than in the optimum habitat occupied by central populations.

MaCall (1983) predicts that peripheral populations are supported by emigration of surplus animals from the central portion of the range to marginal habitat on the periphery of the range. This prediction assumes a healthy central population which appears to be a reasonable assumption for harbor porpoise. Barlow's (1987b) assessment of the west coast population indicates it is at 91% of carrying capacity, and the only incidental take north of Point Reyes is a small take in an Indian set net fishery for salmon around Cape Flattery. Therefore, if harbor porpoise south of Point Reyes are a peripheral stock, MacCall's model predicts there will be immigration and that treating it as a self sustaining population may not be appropriate.

The west coast population of harbor porpoise may be at OSP. However, the apparent susceptibility of this species to coastal gillnet operations increases the possibility that fishing operations may have a significant adverse impact in certain localized areas. Management measures, as have been enacted by the state of California, should be implemented to prevent localized depletions.

Insufficient information is available on abundance and incidental mortality of harbor porpoise in the Gulf of Alaska and the Bering Sea to support assessments of the status of harbor porpoise populations in those areas. Substantial uncertainties exist regarding harbor porpoise distribution and abundance, the relative discreteness of populations or stocks in different areas, the age and sex of porpoise being taken incidentally in California set net

fisheries, and the nature, level, and age-sex composition of harbor porpoise being taken by fisheries in the Gulf of Alaska and the Bering Sea.

Effect of Incidental Take on OSP

The only area where sufficient information is available to assess the impact of incidental mortality on a population of harbor porpoise is in California. The State of California has implemented management measures that will contribute to a substantial reduction in harbor porpoise mortality during the 1987/88 fishing season. NMFS expects that the total mortality for the 1987/88 fishing season will be about 115 porpoise, half of the number taken annually in 1984/85 and 1985/86 fishing seasons.

Barlow (1987b) used a range of 0.0% to 15% for the maximum net recruitment rate of harbor porpoise. He used 7% as a median estimate of the rate. Reilly and Barlow (1986) calculated rates of increase for delphinid populations of up to 9% per year. They stated that the highest rates estimated were probably unrealistic for delphinid stocks because of the combination of high fecundity and low mortality needed to achieve them. Those high rates may not be unrealistic for harbor porpoise, a phocoenid, since this species reaches sexual maturity at younger ages than dolphins and may have a shorter calving interval (Gaskin 1984).

Harbor porpoise reproductive strategy appears to be more similar to harbor seals than to dolphins. Both harbor porpoise (Gaskin 1984) and harbor seals (Bigg 1981) reach sexual maturity at ages between three and five years and are capable of reproducing annually. Rates of increase of 8% (Brown 1988) to 10.7% (Beach et. al 1985) have been documented for harbor seals in Oregon and Washington. The contribution of immigration to those rates is unknown but is probably small since, like harbor porpoise, harbor seal populations seem to consist of small, rather resident groups (Calambokidis 1984). Harbor porpoise have a longer lactation period and are shorter lived than harbor seals, thus the maximum net recruitment rate for harbor porpoise is probably intermediate between dolphins and seals. In this context, Barlow's selection of 7% as a maximum net recruitment rate appears reasonable.

Barlow (1987a) estimated that 1,854 harbor porpoise occur in the geographic area where the fishery occurs. If we assume that these porpoise comprise a population that receives no immigrants, and that it is near but above its MNPL, a net recruitment rate of 3.5% would be expected. This results in a surplus of 65 porpoise. An emigration rate of 0.5% is all that is needed from the area adjacent to the stock to provide the remainder of 50 porpoise. This is a conservative estimate compared to emigration rates that have been observed for elephant seals (LeBoeuf 1980) and it is small enough that it is consistent with the information on pollutants.

The expected level of take in California should not disadvantage harbor porpoise stock in central California because this population can reasonably be expected to sustain the proposed level of mortality without declining, and programs are in place to monitor the levels of incidental mortality and trends in the porpoise population.

Research Needs

To meet the mandates of the MMPA, additional information needs must be satisfied. These information needs can be organized under five major topics: 1) stock structure, 2) distribution, 3) life history, 4) mortality, and 5) population assessments in Alaska.

Stock structure

To ensure that the population is not being disadvantaged by the incidental mortality additional information on stock structure is needed.

a. Tissue loads of pollutants.

A preliminary study of the pollutant loads in the tissues of porpoise led to the concern that small localized stocks may exist along the west coast. The conclusions of the study are preliminary because they are based on small sample sizes and there are large segments of the coast from which no samples were collected and analyzed. Samples from the California coast north of the Russian river need to be collected and analyzed to determine whether animals north of the Russian River are distinct from the animals south of the Russian River. Sample sizes for the entire coast, in particular those from the vicinity of Morro Bay, need to be increased to ensure that the few samples from any particular location are indicative of the stock in that area. Similar analyses need to be conducted in Alaska.

b. Genetic Studies

Several genetic techniques exist for examining stock structure (e.g., recombinant ribosomal and mitochondrial DNA studies). These should be investigated as methods to help define stocks and understand their genetic interactions.

Distribution

Radio tagging studies are needed to provide an independent verification of the nature of harbor porpoise movement patterns. If they could be conducted over a long enough period of time, they could also provide information on seasonal movement patterns. Both Barlow (1987a) and Dohl et al. (1983) document seasonal differences in distribution and abundance. The dynamics of these changes need

to be defined before the effect of incidental mortality on the population can be assessed accurately.

Life History Parameters

Barlow's assessment of the status of the central California population of harbor porpoise indicates that the population is at 29 to 81% of the population size in 1969. Better information on reproductive biology, population growth rates, and mortality patterns is needed to refine the assessment and to determine maximum levels of allowable take. Improved coordination of the stranding network and revised policy or procedures for retention of incidentally taken animals should make more specimen material available for life history studies.

Mortality

Currently the CDF&G estimates of mortality comprise the only information on mortality. The age and sex structure of the kill needs to be determined to better understand the effect of the kill on the population. Assessment of incidental mortality needs to be conducted in Washington and Alaska. Studies are needed to identify changes in fishing practices or other measures that could be taken to avoid or reduce incidental mortality.

Population assessments in Alaska

There are insufficient data available on the status and trends of Alaska harbor porpoise populations to evaluate the potential impacts of incidental mortality in gillnet fisheries. Surveys need to be conducted in all locations where major fisheries occur.

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Harbor Porpoise *Phocoena phocoena* (Atlantic)

Stock Definition

Harbor porpoise are reported in the Northwest Atlantic nearshore waters from Greenland to North Carolina, although North Carolina is beyond the normal southern range of this species. A series of strandings during one season in 1977 are the only observations from this far south. The more typical southern range limit is probably Cape May, New Jersey (Gaskin 1984).

Detailed studies of stock structure in the Northwest Atlantic do not exist; however, four major populations have been recognized (Gaskin 1984). One population occurs in the region from North Carolina to southern Nova Scotia. Data on seasonal distributions, PCB and mercury levels in animals from different parts of this area, and movements of known individuals are all "strongly suggestive of a single population with a mixed north-south and inshore-offshore movement, but one which does not seem to go further than the edge of the continental shelf" (Gaskin 1984). The degree of interchange between this population and animals from the Atlantic coast of Nova Scotia is unknown. Little information exists for harbor porpoise on the Atlantic coast of Nova Scotia but existing observations suggest restricted local use by small seasonal colonies.

Distribution

Harbor porpoise exhibit seasonal patterns in spatial distribution within the region. Their distribution in late summer and early fall appears to be primarily north of Port Clyde, Maine. Harbor porpoise density increases dramatically in the Bay of Fundy/northern Gulf of Maine region during summer and early fall, based on sighting surveys (Gaskin 1984). Kraus et al. (1983) conducted shipboard line transect surveys in coastal waters from Boston to the Canadian border in early July; no harbor porpoise were sighted south of Port Clyde. Similarly, summer aerial CeTAP surveys (Winn 1982) reported only a few animals south of this area.

Harbor porpoise leave the Bay of Fundy area in October/November, although some animals are resident year around (Neave and Wright 1968). With the exception of the CeTAP surveys (Winn 1982), very little survey work has been done during the winter, and the CeTAP surveys sighted only a few harbor porpoise during winter. CeTAP surveys recorded a broad distribution from south of Cape Cod to the Bay of Fundy and extending seaward over Georges Bank during spring. In coastal areas, changes in sighting frequencies suggest a general northeast movement during the spring. Harbor porpoise are commonly sighted in the Cape Cod area during April but no sightings have been reported in this region later in the year (Kraus et al. 1983; Kraus and Prescott 1984).

Population Estimates

No reliable estimate of abundance exists for the total harbor porpoise population from Nova Scotia south. Numerous line transect surveys have been conducted covering a portion of their seasonal distribution (Winn 1982; Gaskin et al. 1985; Kraus et al. 1983). Estimates of abundance from these surveys are variable. Estimates for the western Bay of Fundy during August range from 3,000 to 4,000 animals and estimates for the Gulf of Maine region during July range from 7,000 to 15,000. The highest seasonal abundance estimates from the CeTAP surveys, that encompassed the largest portion of the region inhabited by this population, was 3,541 (+/- 1,486) during the spring for the area from the Gulf of Maine south. These estimates cannot be integrated to cover the entire range because of the seasonal changes in harbor porpoise distribution and the differences in the timing of the various surveys. In addition, estimates from all of these surveys should be considered preliminary and used with caution. Survey methodology for harbor porpoise is not well developed and many of the assumptions of line transect theory used to derive the abundance estimates are not adequately accounted for in the analyses (Polacheck et al. in prep.).

Incidental Take in Fishery Operations

Harbor porpoise are killed incidentally in the Canadian summer gillnet fishery in the Bay of Fundy and the United States Gulf of Maine gillnet fishery. Based on phone interviews at the end of the fishing season, estimated total kill by Canadian gillnetters was 105 in 1986 and 129 in 1987 (Read 1987 and pers. comm.; Read and Gaskin in press). From these incidental kills, 73 animals were collected for analysis by Canadian research scientists in 1987. Read estimated a kill rate of 0.37 porpoises per boat-day-fished on closely monitored vessels in 1986. This was consistent with the estimate for that year (Read 1987; Read and Gaskin in press).

Estimates of the total kill by United States gillnetters do not exist. Permits for incidental take of marine mammals were issued to 11, 22, and 11 gillnetters in 1984, 1985, and 1986, respectively (Gilbert and Wynne 1988). In 1984 and 1985, 7 and 13 of these permit holders reported their take. The number of harbor porpoise reported killed by these permit holders was 30 and 107 or 4.3 and 8.2 animals per fisherman per year. The 1986 reports are incomplete. Observations from 8 trips during 1984 and 1985, representing 1,075 net-days of fishing, suggested a kill rate of 0.0037 animals per net-day-fished or 0.5 animals per trip.

The reported number of harbor porpoise killed by permit holders (30 and 107 in 1984 and 1985 respectively) is a lower bound for the total kill by U.S. gillnetters, since only a fraction of all gillnetters participated in the permit program. A reliable

extrapolation of the reported kill rates to the entire fishery is not possible for three reasons:

(1) The total number of gillnetters fishing in the coastal waters of Maine, Massachusetts and New Hampshire is difficult to ascertain. Much of the fishing is done by vessels less than 5 gross tons that carry several gear types and participate in various fisheries. Data on these vessels are not individually recorded in the commercial fishery statistics system maintained by NMFS. The maximum number of gillnetters over 5 gross tons landing groundfish in any single month in 1984 was 64 (Gilbert and Wynne 1988).

(2) The sample of gillnetters for which incidental kill information is available cannot be considered representative of the entire fleet. Permit distribution was focused on ports where incidental captures were reported to be most frequent; and offshore boats, which report only very infrequent encounters with marine mammals, were not included in the sample (Gilbert and Wynne 1988).

(3) Incidental kill rates would be expected to vary both geographically and seasonally, but information on both incidental kill rates and gillnet fishing effort stratified by area and season are not available.

Taking into account these uncertainties, Gilbert and Wynne (1988) suggest that an upper bound for the annual number of harbor porpoise killed would be around 600 animals based on the average take of 5.1 porpoise per gillnetter per year reported by permit holders in 1984 and 1985 and an estimated 90 to 120 New England gillnetters. Because of the sampling biases noted above, they consider 600 animals a year to be an upper bound and suggest that the annual take is actually somewhere between the number reported by permit holders and 600.

Gillnet effort in the New England region increased during 1985-86 by about 10% (NEFC 1987), and increased another 10% in 1987, based on commercial catch and effort statistics for vessels larger than 5 tons. Port agents report that 20 additional gillnetters have been added to the fleet in 1988. Therefore, unless this increased effort is in areas uninhabited by harbor porpoise, incidental kills are likely to have increased from 1984 and 1985 levels.

Harbor porpoise also are entrapped in herring weirs. Smith and Gaskin (1983) report an average annual take of 0.328 harbor porpoise per weir for 1981 in Charlotte County, New Brunswick, Canada (Bay of Fundy). They estimated that 70 animals were trapped in 216 licensed weirs in 1981 and 27 (38%) died. More recent estimates of kill rates or kills from herring weirs are not available, but the number of operating herring weirs has remained relatively constant for Charlotte County (Read pers. comm.).

No information is available on incidental takes in herring weirs in U.S. waters. The number of herring weirs operating in Maine has decreased (76 weirs in 1985, 22 in 1986, and 12 in 1987).

Subsistence hunting for harbor porpoises by Passamaquoddy Indians has also been reported (Prescott and Fiorelli 1980; Smith et al. 1983). Smith et al. (1983) suggested that the total kill by native hunters was between 5 to 10 animals per summer in the early 1980s. Researchers in this area have not noted any sign of porpoise hunting recently and believe that it may have stopped completely (S. Kraus and A. Read pers. comm.).

Optimum Sustainable Population (OSP)

No OSP estimate has been developed for this population.

Effect of Incidental Take on OSP

Current incidental kills may be having an impact on harbor porpoise populations in the Gulf of Maine. The incidental kill of 129 porpoises in the Canadian gillnet fisheries in 1987 would require that the total population size be greater than 13,000 for the incidental kill to remain below 1% of the population. If the number of animals killed by the other fixed gear fisheries (i.e., U.S. and Canadian herring weirs, and U.S. gillnetters) exceeded 70 animals in 1987, which is likely given the kill rate information presented above, then the total kill would exceed 200 animals per year. A kill of 200 animals per year would require that the total population size be greater than 20,000 for kills to remain below 1% of the total population. A population size of 20,000 animals exceeds the upper limits of abundance estimates obtained in all surveys to date. Read and Gaskin (in press) suggest that the combined U.S. and Canadian kills may be as high as 7.5% of the total population.

Read (1987 and pers. comm.) and Read and Gaskin (in press) report a decrease in the proportion of mature females in the population and a shift in the overall size distribution towards smaller, younger animals in samples collected in 1981-86, compared to samples collected in 1969-73. A shift in the age distribution toward younger animals is expected in a population under exploitation and may be an indication that the current incidental kills are significant.

Research Needs

Several additional research activities need to be undertaken to evaluate the status of the harbor porpoise populations and the effects of the current levels of incidental take. Some of these tasks require and all would benefit from cooperation with Canadian researchers.

Determine a reliable estimate of size of the population using shipboard line transect surveys (see Polacheck and Smith 1988; Polacheck et al. in prep.).

Compare data from east and west coast surveys (e.g., distribution relative to water depth, time of year, distance from shore, and number and size of groups seen per survey mile) to help determine the most appropriate ways for extrapolating the data to develop population estimates and improve survey techniques.

Obtain better information on the nature and size of the incidental take and examine these data to identify changes in fishing practices or other measures that might help prevent or reduce incidental take.

Determine levels of incidental kills by U.S. fixed gear fisheries operations in New England including estimates of kill rates and total fishing gillnet effort by area and season.

Determine life history parameters of animals taken incidental to fixed gear fisheries through collection of data and specimen material.

Determine stock structure and seasonal distribution.

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Dall's Porpoise *Phocoenoides dalli*

Stock Definition

Dall's porpoise (*Phocoenoides dalli*) are widely distributed across the entire North Pacific Ocean. Four color morphs exist. The truei morph is black with a white flank patch extending forward as far as the flippers, and a white throat patch is present; it is common along the Pacific coast of Japan. The dalli morph is more cosmopolitan; the white flank patch does not extend forward beyond the dorsal fin, and there is no white throat patch. The third morph, which is uncommon, is a solid black form occurring along the Sanriku coast of Japan (Kasuya 1982) and in the northwestern Pacific (NMFS/NMML unpubl. data). All gray or all white animals are observed rarely (Joyce et al. 1982). Dall's porpoise occur predominantly offshore but may be inshore in some areas. In the eastern North Pacific, they have been sighted as far south as 28°N (Leatherwood and Fielding 1974) and in the central North Pacific south to at least 39°N (NMFS/NMML unpubl. data). The southern limit coincides with the 17° to 18°C isotherm (Kasuya 1982; Kasuya and Jones 1984). The northern limit is generally Cape Navarin, U.S.S.R. (62°N). Kasuya (1982) suggested that three populations exist in the western North Pacific and adjacent areas: the truei morph constitutes a discrete population occurring off the Sanriku coast as far east as 180° longitude, migrating northward in winter; it overlaps with the dalli morph between Japan and the Aleutian Islands (Kasuya and Shiraga 1985). The population in the Sea of Japan, Okhotsk Sea, North Pacific and Bering Sea is the dalli morph. Separate populations have been suggested for the eastern and western North Pacific (Yoshioka et al. 1987).

Distribution

Dall's porpoise are found over the continental shelf adjacent to the slope and over deep oceanic waters (2500+ m;Hall 1979). The only apparent distribution gaps in Alaskan waters are upper Cook Inlet and the shallow eastern flats of the Bering Sea. Throughout most of the eastern North Pacific, they are present during all months of the year, although there may be seasonal onshore-offshore movements along the west coast of the U.S. (Loeb 1972; Leatherwood and Fielding 1974) and winter movements of populations out of Prince William Sound (Hall 1979) and areas in the Gulf of Alaska and Bering Sea (NMML unpubl. data). In the western North Pacific, changes in incidental catch rates by latitude and month reflect a migration northward from early spring until early autumn (Ohsumi 1975). Kasuya (1982) suggests that the truei morph in Japanese Pacific coastal waters migrates north in winter.

The reproductive cycles of animals in the Bering Sea and western North Pacific are apparently out of phase. No newborn porpoise have been sighted or caught in drift nets in the Bering Sea during June and July; however, up to 59 newborns are collected each year in the western North Pacific during these months. The percentage of lactating females in the Bering Sea is 10%, compared to 46% lactating in the western North Pacific during those months. There are no lactating females present in the Bering Sea until mid-July when the majority of females in the southern area are already lactating. Some separation is thus indicated between the Bering Sea and North Pacific populations (Jones et al. 1986).

Population Estimates

Estimates of Dall's porpoise abundance during the period 1978 to 1987 are based on sighting surveys conducted by U.S. observers aboard Japanese salmon research vessels and U.S. vessels utilized by the National Marine Mammal Laboratory's (NMML) Platforms of Opportunity Program (POP). The estimate of the total of the populations of Dall's porpoise in the Bering Sea and North Pacific Ocean (except the Sanriku coast stock) ranges from 1,500,000 to 2,100,000 (Bouchet et al. 1986; Jones et al. 1986; Turnock 1987).

Incidental Take in Fishery Operations

The Japanese high seas salmon mothership fishery has been operating in the North Pacific since 1952. The estimated annual incidental take by the Japanese in this fishery (1981 - 1987) within the U.S. Exclusive Economic Zone (EEZ) ranged from 741 (1987) to 4,187 (1982). The mean take rate for observed salmon gillnet operations from 1981 to 1985 was 0.47 porpoise per set (15 km of net) inside the U.S. EEZ. The estimated incidental catch outside the U.S. EEZ ranged from 479 to 1,716 (Jones 1987; Jones et al. 1986). There has been no monitoring by U.S. observers of the incidental take by the Japanese land based salmon fishery. If the mean observed take rates in the mothership fishery apply to the land based fishery, the estimated annual take would range from 2,936 (1981) to 6,010 (1982).

Incidental take by the Japanese squid fishery was reported (by the Fisheries Agency of Japan based on reports by the fishermen) to be 2,500 in 1982, 2,502 in 1983 and 2,515 in 1984. There is currently no monitoring of the high seas squid gillnet fishery, although some observations of the incidental take have been made on foreign commercial and research vessels. The incidental take of Dall's porpoise in the Korean and Taiwanese squid gillnet fisheries is unknown. Dall's porpoise are incidentally taken in gillnets and purse seines in Alaska and Puget Sound, in trawl nets in Alaska and on the west coast, and in shark nets off the west coast (NMFS/NWR unpubl. data).

Optimum Sustainable Population (OSP)

Over the period 1980-1984, the yearly population estimates for Dall's porpoise did not differ significantly (Jones et al. 1986). The Bering Sea stock is believed to be at a population level which is roughly 78% to 94% of its pre-exploitation (1952) size. The western North Pacific stock is estimated to be between 66% to 91% of its pre-exploitation size (Jones et al. 1986). Thus, these stocks are considered to be within OSP.

Effect of Incidental Take on OSP

Under current regulations of the International North Pacific Fisheries Commission (INPFC), foreign fishing effort in the Bering Sea is being phased out and is to be terminated by 1992. The stock of Dall's porpoise in this area is estimated to be at 78 to 94% of its unexploited population size. With reduced fishing effort, it is unlikely the population would decline below OSP prior to the termination of fishing.

In the western North Pacific, the Dall's porpoise population is caught by both the land based and mothership salmon fisheries and by the three squid fisheries. Fishing effort by the salmon fisheries has declined in recent years; however, the fishing effort by the squid fleets has remained high or possibly increased. Without reliable information on the incidental take by the squid fisheries, the impact of the fisheries on the western North Pacific population of Dall's porpoise cannot be reliably determined. An Administrative Law Judge determined in 1987 that at the 1986 levels of fishing effort and incidental take rates of 0.33 porpoise per 15 km of net in the land based salmon and squid high seas fisheries, and 0.47 in the mothership salmon fishery, there would not be a level of take that would cause this population to decline.

The assumed eastern North Pacific population of Dall's porpoise is incidentally taken by the three high seas squid drift net fisheries. There is insufficient information on incidental take by these fisheries to reliably estimate the annual take. Given an estimated population size in the eastern Pacific of over 600,000 (Jones et al. 1986), and an incidental take that may be lower than that in the western Pacific, the impact on this population may be less than the combined fisheries are to the populations in the western Pacific and Bering Sea.

Research Needs

Additional research is needed on Dall's Porpoise to:

Assess and monitor the status of populations.

1. Design and conduct surveys to determine abundance of each population and determine how factors such as the response of animals to survey vessels affects abundance estimates.

2. Monitor incidental take in all fisheries.

3. Collect biological samples and data to determine biological parameters such as age at first reproduction, age structure, and reproductive rates for each population and monitor trends in the parameters.

Determine discreteness of populations and the boundaries of each.

Determine the habitat of Dall's porpoise and study how oceanographic and biological factors influence abundance and distribution.

Determine food habits and feeding behavior in fishery areas to understand the relationship between the porpoise and the fishery to develop management options.

Develop gear modifications to reduce entanglements.

Study acoustic and visual capabilities of porpoise to design gear modifications.

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Bottlenose dolphin *Tursiops truncatus* (Pacific)

Stock Definition

Although there is disagreement among taxonomists regarding the genus *Tursiops*, there are morphological and behavioral differences between Atlantic, Pacific, and perhaps other localized forms. Most current taxonomic opinion places all bottlenose dolphins in the single polymorphic species *T. truncatus*. The opinion among marine mammalogists is that there are probably three forms in the North Pacific: a coastal form, occurring inshore along southern California and Mexico, a northern temperate offshore form, and an eastern tropical Pacific (ETP) offshore form (Walker 1981). The name *T. gilli* has been applied by some workers to the larger, lighter-colored coastal form. Walker (1981) identified the ETP form to correspond to *T. nuuanu*. While definitive systematic work has not yet been done to resolve the specific or subspecific status of these forms, most workers consider these as nominal species synonymous with *T. truncatus* and best considered as separate stocks.

Distribution

Bottlenose dolphins are common in the coastal waters of the western United States south of Pt. Conception, although there have been occasional sightings recently as far north as Santa Cruz (Wells et al. in press) and one was sighted in Puget Sound, Washington in the summer of 1988. The range of the species in the eastern Pacific Ocean extends beyond the United States-Mexican border into the eastern tropical Pacific Ocean (Leatherwood et al. 1982). The coastal form inhabits shallow water just beyond the surf, and in bays and estuaries from Santa Monica Bay, California south along the coast of Baja California, Mexico and into the Gulf of California (Hansen in press). The northern temperate offshore form inhabits offshore waters from southern California south; the southern limit of the range depends on an unknown relationship to the ETP population (Walker 1981).

Information on movement of bottlenose dolphins and their degree of intermixing is limited. However, behavior and tagging studies in the Gulf of Mexico strongly suggest that some local groups with limited home ranges may be "resident" populations (Shane et al. 1986). Photo-identification studies of the coastal population (Hansen in press; Defran et al. 1986) have not shown a seasonal pattern in distribution or a well-defined home range; movements involve frequent but irregular travel over fairly long portions of the coastline.

Dohl et al. (1980) reported seasonal increases or concentrations of bottlenose dolphins, presumably of the northern temperate offshore stock, around Catalina Island during autumn and winter periods.

These studies focused on the Southern California Bight in general and did not separate sightings into stocks. Most of the bottlenose dolphins observed were in relatively shallow water (mean depth 42 fm) around offshore islands and along the mainland coast.

It has been suggested that offshore stocks may intermix with the coastal population or emigrate to inshore localities, providing additional sources of recruitment for coastal stocks. However, this can not be confirmed since studies examining movements of identified individuals from the coastal and northern offshore stocks have not been conducted.

Population Estimates

No accurate estimates of population sizes exist for stocks in Pacific Ocean waters off the United States. The species has been characterized as "abundant" and "common" off southern California. If the population of the small, dark northern offshore form is indeed continuous with the tropical population(s) of ETP bottlenose dolphins to the south, the overall population can be assumed to be at least in the tens of thousands. The Southwest Fisheries Center in 1976 estimated a population of 88,466 from an expansion of the aggregate total of sightings of bottlenose dolphins and rough-toothed dolphins, *Steno bredanensis* (the two species are easily confused at sea) made by NMFS observers aboard commercial tuna seiners south of San Diego in 1975 and 1976.

The size of the United States portion of the large, light-colored coastal form has been estimated to be between 240 (Hansen in press) and 318 (Defran et al. 1986). A number of such localized populations may exist, with little or no contact between groups off southern California and off Baja California and in the Gulf of California.

Dohl et al. (1980) estimated that as many as 925 bottlenose dolphins were present in the Southern California Bight (SCB) during 1975-1978. These estimates presumably included both the coastal and northern temperate offshore forms.

Incidental Take in Fishery Operations

Although studies of incidental marine mammal mortality conducted by the California Department of Fish and Game (CDF&G) have not observed taking of *T. truncatus* in California fisheries, a few stranded individuals are found each year with marks providing circumstantial evidence for fisheries related mortalities (NMFS, Southwest Region files). Thus it seems likely that a few *T. truncatus*, probably of the coastal stock, may be taken in monofilament gill and trammel nets set in shallow water off southern California and Mexico.

Mixed-species groups of pelagic dolphins also occur off California, and it can be assumed that the local seine fishery for blue fin tuna, bonito, mackerel, squid, and anchovy (the "wetfish" fishery), which has been observed to incidentally take white-sided and common dolphins, may also take some bottlenose dolphins.

In addition to these incidental takes, there has been some directed take. A few coastal animals may be taken for food in Mexico. A few (ca. 15) animals of both the coastal and northern temperate stocks have been captured off southern California and in the Gulf of California for public display (Walker 1975).

Optimum Sustainable Population (OSP) and Effect of Incidental and Directed Take on OSP

OSP cannot be estimated for the northern temperate offshore form because of the uncertain estimates of population size and incidental take. However, the population of the northern temperate offshore form is fairly large relative to any potential incidental take. Thus, it is likely that this stock is at or near carrying capacity and above the lower bound of OSP.

The situation for the coastal form is not clear. Early directed takes may have been significant because of the apparent small population size. For example, in two live-capture operations in 1957, 5 animals were captured alive and at least 3 killed out of a school of 25-35 animals resident in San Diego Bay and environs. Similar live-capture operations have been carried out near Isla San Felipe in the Gulf of California. NMFS's Southwest Fisheries Center (SWFC) has estimated roughly that maximum net productivity for a dolphin population (the lower bound of OSP) is about 2 percent (Reilly and Barlow 1986). Thus, the recruitment for a coastal stock of about 300 is 6 individuals per year. Removals above this level are likely to have long-term implications for the status of a local stock relative to its OSP.

Research Needs

Data are needed to:

1. Conduct surveys of population size and seasonal distribution on a stock basis. (Conduct aerial and/or ship census surveys.)

2. Continue to monitor incidental take of marine mammals in California fisheries. (Collect data on incidental take in fisheries. In particular, examine beach-stranded specimens to determine cause of death.)

3. Analyze the stock discreteness of the Pacific bottlenose dolphin form(s):

a. Determine the taxonomic relationships of the various Pacific forms assigned to the genus *Tursiops*. (Carry out comparative morphological studies based on external measurements, photos and osteological specimens.)

b. How far offshore does the habitat of the coastal form extend? (Monitor radiotagged animals; conduct photo-identification studies in the SCB.)

c. How much coastline does the home range of a single school include? In particular, examine distribution into areas south of the US-Mexico border and north of San Pedro Bay. (Monitor radiotagged animals and observe movements of photo-identified individuals.)

d. Determine the potential for and extent of reproductive exchange between the two forms present in the SCB. Determine the gross reproductive rates. (Conduct studies of genetic composition. Examine sex and age structures of schools and collect reproductive data from beached carcasses.)

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Bottlenose Dolphin *Tursiops truncatus* (Atlantic/Gulf)

Stock Definition

Stock or population structure of the western North Atlantic and Gulf of Mexico bottlenose dolphin is not completely known, although distribution data suggest the existence of near-shore/offshore populations as has been suggested along the west coast. In the southeast, a working hypothesis for stock structuring is that there are local, resident stocks in certain embayments and that transient stocks migrate into and out of these embayments on a seasonal basis (Scott in press; Hersh 1987a). In addition, there appears to be both near-shore and offshore forms (stocks) of bottlenose dolphin along the U.S. Atlantic coast and in other ocean areas (Hersh 1987a,b). Based on stranding data collected during 1987 and 1988 along the U.S. Atlantic coast, there appears to be a coastal migratory group that ranges seasonally as far north as Long Island, NY and as far south as central eastern Florida.

Distribution

Bottlenose dolphins are distributed throughout U.S. Atlantic and U.S. Gulf of Mexico waters. In the U.S. Atlantic region, these dolphins are distributed along the coast from Long Island, NY to the Florida Keys. North of Cape Hatteras, there appears to be a disjunct near-shore/offshore distribution, with concentrations of animals near-shore (in embayments and within several kilometers of shore) and offshore (60-200 kilometers from shore) near the continental shelf margin. South of Cape Hatteras, the near-shore/offshore distribution is less distinct, with apparent latitudinal clusters of animal concentrations, in contrast to the longitudinally discrete concentrations found to the north. In the U.S. Gulf of Mexico, aerial survey data indicate that bottlenose dolphins occur from backwater bays, offshore at least to waters 200 m deep. The available data suggest that the bottlenose dolphin distribution in the Gulf is clumped rather than distinctly near-shore/offshore as occurs north of Cape Hatteras. It has been well documented that there are both resident and transient animals that utilize localized, near-shore environments over numerous years.

There are seasonal changes in the distribution of bottlenose dolphins in both the U.S. Atlantic and Gulf of Mexico. In the U.S. Atlantic during summer, bottlenose dolphins are distributed along the coast from the Florida Keys to usually as far north as Long Island, and offshore as far north as Nova Scotia, Canada. During fall, it appears northern near-shore Atlantic animals migrate south along the coast to Florida. In the winter, the Atlantic animals are distributed from Cape Hatteras south to the Florida Keys, but the majority of these animals appear to be concentrated along the northeastern and central Florida coast. During spring, the animal

concentrations shift northward to complete the hypothesized migratory cycle. It is unclear if the Atlantic offshore portion of the population follows the same pattern. Seasonal changes in the Gulf of Mexico are not as clear as in the Atlantic. However, it has been observed that many geographically localized populations of dolphins in the Gulf and Atlantic waters show seasonally cyclical patterns in abundance suggesting emigration from and immigration into embayments.

Population Estimates

At present there is no comprehensive estimate of the size of the stock(s) of bottlenose dolphins in southeastern U.S. jurisdictional waters. Data sufficient for seasonal estimates of dolphin abundance throughout these waters have been collected, but await final analysis. However, the abundance of bottlenose dolphins in certain regions in the southeast has been estimated. Based on these estimates, and those from CeTAP (1982) and Fritts et al. (1983), the number of bottlenose dolphins in the eastern U.S. regional waters prior to 1983 may have ranged to at least 23,000. Extrapolation of this estimate to existing abundance, however, assumes that the stocks have been stable over a period of 15 or more years and that no net migration occurred during the respective sampling periods.

In at least one case, it is known that the assumption of a stable stock level is unlikely. Between June 1987 and April 1988, an unusually high number of bottlenose dolphins stranded along the beaches from New Jersey to Florida due to a disease epidemic. The stranding rate remained abnormally high during the summer, fall, and winter months. The areas of stranding activity changed with the seasonal pattern of migration of dolphins (Burn 1988).

Historically, about 15,000 animals are thought to have lived in mid-Atlantic near-shore waters, based on North Carolina shore-based fishery catch records from the turn of the century (Mead 1975). In 1979-81, the estimated average mid-Atlantic summer abundance of bottlenose dolphins is believed to have ranged from 4,300 to 12,900 animals (95% confidence region, CeTAP 1982) including both the near-shore and offshore groups. The best available information suggests that in recent times coastal North Carolina and Virginia supported 1,200 or more dolphins during part of the spring and summer (J.G. Mead, Smithsonian Institution, pers. comm.) This number may have represented a substantial portion of the mid-Atlantic near-shore population during summer months. Population survey samples taken in August, 1987 resulted in estimates ranging from 1,950 to 7,500 animals in the offshore mid-Atlantic, and from 350 to 1,300 animals in the near-shore mid-Atlantic (NMFS/SEFC unpubl. data; Scott and Burn 1987). The recent estimates (1979-81 and 1987) may be conservative and represent estimates of surface abundance only.

Hersh (1987c) summarized the literature available on mortality rates for bottlenose dolphins and related species. She reported that rates on the order of 7-14% per year were believed to encompass the most likely range for bottlenose dolphin populations. During the 11 month period from June 1987 to April 1988, a total of 742 stranded bottlenose dolphins were reported from New Jersey to Florida's east coast to the Smithsonian Institution's marine mammal stranding events program. In the prior 3 years (1984-1987), for the same geographical range and months (June through April), an average of 73.33 dolphins were reported to the stranding network. Thus, the 1987-88 anomaly represents an order of magnitude increase (10.11 times) in reported strandings relative to the most recent three year historical level. Assuming that the stock's natural mortality rate (m) is at the lower end of the reported range (7% per year, 6.42% per 11 months), and that the observed mortality wholly affected the near-shore stock, and further assuming that the reported stranding rate is proportional to m and consistent between years, then the observed mortality represents an 11 month m of 64.9%.

The annual rate of change in dolphin stock abundance is the difference between the annual mortality rate, annual birth rate and annual net immigration rate. For the coastal mid-Atlantic stock of dolphins affected by the disease epidemic, Baylock (1984) observed that up to 11.5% of the population sampled was calves, implying an annual birth rate (b) on that order. Data collected from stranded animals suggests that calving for this stock occurs in the spring and is not generally protracted over the year. Given no net immigration, a potential decline for this stock since early 1987 is estimated as over 50% (b-m = -53.4%).

Incidental and Directed Take in Fishery Operations

The present take of bottlenose dolphins in U.S. waters comes from the live-capture fishery for public display, incidental take in other fisheries, and by the shooting of "nuisance" animals. The reported removals from the population of bottlenose dolphins in southeastern U.S. waters for public display and scientific research purposes since 1972 has been documented by Scott (in press). Leatherwood and Reeves (1982) summarized the history of the live-capture fishery, dating as far back as 1914 and report it to be the longest sustained fishery of its type in the world. They estimated that at least 1,500 animals have been removed from the waters of the U.S., Mexico, and Bahamas for public display and scientific research purposes. From the southeastern U.S. waters, they estimated that at least 1,170 have been removed.

The magnitude of annual removals due to incidental take and shooting of nuisance animals is not well documented. Several data sources suggest that incidental catch is occurring in several fisheries. The fisheries known to be involved include: menhaden purse-seine fishery, shrimp trawl fishery, and the foreign fleet

fisheries (Leatherwood and Reeves 1982; R. Ford pers. comm.). Some mortality also occurs when these dolphins become entangled in the float lines of lobster or crab traps (Leatherwood and Reeves 1982). Other fisheries which trawl or use seine nets and the drift gillnet fisheries may also take bottlenose dolphins. The level of incidental take is difficult to assess because most of the information is anecdotal. However, take has been documented in the shrimp trawls (B. Schroeder, NMFS, pers. comm., 1988), high opening bottom trawls (R. Ford, NMFS, pers. comm., 1988), menhaden purse-seines (MMPA permit application), and the foreign mid-water trawl fishery.

According to Reynolds (1985), bottlenose dolphins are incidentally taken in a variety of fisheries throughout the southeastern U.S. Annual estimates for North Carolina were 12-18 animals per year by cast nets, seine nets, purse seines, shrimp trawls, and gillnets. For South Carolina, 12-15 per year were estimated to have been taken in sturgeon and shad gillnets. Incidental take in Georgia is described as relatively few individuals per year. On the east coast of Florida, incidental take is considered generally low, and is attributed to such sources as gillnetting, shooting, and collisions with boat propellers. On the west coast of Florida, approximately 6 animals per year are thought to be killed by fish nets, shrimp nets, shooting, and boat propellers. Total estimated incidental take from Alabama, Mississippi, and Louisiana is 7-11 per year in shrimp trawls, gillnets, menhaden purse seines, and by shooting. In Texas, several dolphins per year may be killed by shrimp trawls, menhaden purse seines, shooting, and boat propellers. Reynolds (1985) noted the discrepancy between the estimated incidental kill from his survey and the (lower) number reported killed by the menhaden fleet under its incidental catch permit, but was not able to resolve the difference. He further noted a potentially large impact by shrimp fleets.

NMFS foreign fishery observers reported 9 takes of bottlenose dolphins incidental to mid-water trawl fisheries for *Loligo* squid and mackerel in the shelf and slope waters off the northeast U.S. between March 1977 and April 1988 (Waring et al. 1988). Observer data for the Japanese longline fishery in the Atlantic show an incidental take of 4 bottlenose dolphins between 1978 and 1987. The shelf edge distribution of bottlenose dolphins in the northeast region limits their interactions with foreign fishing vessels because the latter are restricted to water depths less than 100 m.

The Southeast and Northeast U.S. Stranding Networks provide some information on fishery or human-induced mortality of cetaceans in the Gulf of Mexico and along the U.S. Atlantic coast. Many of the cetaceans which strand within jurisdiction of the networks are examined for causes of mortality. Approximately 1,000 stranded bottlenose dolphins were examined by the networks from 1982 through May 1987, and nearly 7% showed some signs of human-induced

mortality. Assuming that the stranding data indexes human-induced mortality in proportion to natural mortality, interaction problems may exist in several areas. The levels of possible human-induced mortality were highest along Virginia (20% of observed) and Georgia (16% of total), and may indicate a potentially serious fishery interaction problem. Bottlenose dolphins which stranded along Texas, Louisiana, Florida, and North Carolina also showed signs of human-induced mortality, varying from 5-7% of the observed mortality.

Optimum Sustainable Population (OSP)

In general, available data on each of the presumed bottlenose dolphin stocks are insufficient to make determinations about stock status relative to OSP. However, information on the mid-Atlantic coastal migratory group of bottlenose dolphins suggests that this stock is below OSP because it was probably reduced by more that 50% by the disease epidemic. By analogy with other large mammal populations, the population level expected to result in maximum net productivity (the lower bound of OSP) for bottlenose dolphins is greater than 50% of carrying capacity. Thus, assuming a stock reduction of more than 50% and a stable carrying capacity, this stock is likely to be below OSP.

Effect of Incidental Take on OSP

Since the magnitude of the incidental take for each stock has not been documented, only the potential impact of the estimated relative mortality due to human interactions can be evaluated. Although fishery conflicts may represent only a portion of estimated human-related mortality, the overall proportions can be used to gauge the possible magnitude of fishery effects. Based on the stranding data available, human-induced mortality proportions (p) ranged from 0-20%, depending on area of reporting. The highest proportions of human-related mortality are from animals investigated along the Virginia and Georgia coasts. Using the range of natural mortality rates (m) reported by Hersh (1987a, 7-14%), the additional mortality rate due to human-related activities (f) can be estimated by these proportions ($f = m((1-p)^{-1}-1)$). Overall, the estimated human-related deaths result in estimates of added mortality of 0.5-1.0% per year. For the Virginia data, the estimated additional mortality due to human-related activities ranges from 1.8-3.5% per year, while the data from Georgia result in estimates of added mortality of from 1.3-2.6% per year. For the other states, the estimated added mortality is less than 1.1% per year. These stranding data are representative of geographical ranges that may encompass one or more localized stocks, thus the impact on a localized stock could be higher if the mortality is focused on that stock. Alternatively, state-specific estimates might be positively biased if they are representative of only a portion of the stock.

Assuming that maximum net productivity (MNP) is on the order of 2% per year, then the dolphin stocks affected by fishery conflicts can sustain total long-term average human-related mortality rates of 2% per year or less, and still attain equilibrium population levels within OSP range. If true MNP is less than this value, then the corresponding long-term sustainable mortality is less and vice versa. Total human-related mortality in this case includes any removal from the wild population due to other than natural causes.

In the case of the coastal, migratory dolphin stock along the mid-Atlantic, the available data suggest that fishery conflicts, in combination with other human-related deaths, could add sufficient mortality to prevent that stock from attaining OSP, and possibly force a decline in stock abundance.

Research Needs

To evaluate the status of the bottlenose dolphin populations in the Atlantic and Gulf of Mexico and the effects of the current levels of incidental take, several additional research activities need to be undertaken, including:

Determine the mixture of stocks occurring in the east coast mortality anomaly.

Apply recent improved analytic techniques for cetacean sighting survey data to evaluate the reliability of abundance estimates based on CeTAP and NESSP data.

Determine the effects of dumping activity at the 106-Mile dumpsite on dolphins via their prey and bioaccumulation analysis of tissue specimens.

Obtain necessary population survey samples to determine the magnitude of change due to the 1987-88 east coast disease epidemic for both the nearshore and offshore dolphin groups.

Develop consistent time-series database for monitoring the populations of dolphins throughout their range and to monitor the disease affected population's response to depletion.

Compile time-series removal records (incidental catch plus other human-induced removals) from available data sources and estimate potential effect on stocks.

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Common Dolphin *Delphinus delphis* (Pacific)

Stock Definition

Common dolphins are a pelagic species distributed worldwide in temperate to tropical waters of 12° to 28°C. The Atlantic Ocean form exhibits some morphological and clear geographical separation from the Pacific Ocean forms, although they have not been afforded separate specific or subspecific status. Pronounced variations in skull morphology and meristics, overall body size, shape, and coloration have been used to delineate six distinct populations in the eastern Pacific Ocean (Perrin et al. 1985).

Evans (1975, 1982) identified two stocks of common dolphins in California waters. One is a form he called "northeastern Pacific - temperate short snout" which occurs offshore from about Isla Cedros north; and the second is and a larger, longer snouted form called the "Baja neritic" which occurs close to the coast from San Diego County south to the Islas Tres Marias and along the coast in the Gulf of California. Based on the work of Evans, Perrin et al. (1985), and others, four other stocks, comprising a total of three "management units", have been identified for the eastern Pacific Ocean and southern temperate waters ("northern", "central", "southern" stocks).

Perrin et al. (1985) recommended that within 100 nm of the Pacific coast of Baja California schools of common dolphins should be identified as either "northern temperate" (Evans' northeastern short snout) or "Baja neritic" based on modal length, coloration, and relative beak length. Questions concerning the degree, if any, of reproductive isolation between the various forms or stocks have yet to be resolved.

Distribution

In the northeastern Pacific Ocean, the primary distribution of this species is from the California-Oregon border to Costa Rica. Leatherwood et al. (1982) reported a stranding of *D. delphis* at Victoria, British Columbia. A few sightings are reported sporadically between Point Conception and Monterey Bay (Barlow, pers. comm.; Dohl et al. 1983; Christmann 1983; and others).

Large populations occur off southern California (Santa Barbara to San Diego), the west coast of Baja California, Mexico (Islas Cedros to Cape San Lucas), and Costa Rica. A relatively large population also occurs in, and may be a resident of, the Gulf of California. In southern California waters, *D. delphis* is present throughout the year, but is most abundant from August to December. Large numbers of *D. delphis* enter the Southern California Bight (SCB) from the south, apparently following the major undersea ridges and escarpments (Hui 1985), moving in a counterclockwise direction

(Dohl et al. 1986). An observed decrease in herd size during the warmer water months of summer and fall may be due primarily to a breaking up into small subgroups of 50 to 200 animals and a general movement offshore and northward. In the winter and spring months (January to June), sightings generally are confined to the southeastern part of the SCB. Unfortunately, studies of distribution and abundance have not distinguished between the two stocks thought to occur off California.

Population Estimates

The common dolphin is the most abundant cetacean in California waters. No population estimates exist for the common dolphin in California waters on a stock-by-stock basis. As with bottlenose dolphins, the more onshore "Baja neritic" population can be assumed to be smaller than the high seas "northern temperate" population because of its more restricted range and habitat. Dohl et al. (1983) produced the following estimates of (undifferentiated stock) abundance for the SCB: winter-spring - 15,448; summer-autumn - 57,270.

Incidental Take in Fishery Operations

The common dolphins occurring off California probably do not belong to the same stocks as those taken incidentally in the Eastern Tropical Pacific (ETP) tuna seine fishery. However, ETP vessels are involved occasionally in the "wetfish" seine fishery for bluefin tuna (a temperate species), bonito, mackerel, squid and anchovy, offshore southern California and Baja California, Mexico. In 1977, NMFS observers aboard small ETP seiners observed 24 net sets on bonito, *Sarda chilensis*. These sets took 403 tons of bonito and resulted in the incidental mortality of 23 common dolphins; these animals belonged presumably to the "northern temperate" stock. Crude extrapolation to a bonito catch of 11,000 tons yields a rough estimate of 628 common dolphins killed incidentally in the U.S. bonito seine fishery during 1977 (Collins et al. 1979).

Information on the incidental mortality of marine mammals in California fisheries has been collected by the California Department of Fish and Game (CDF&G) since 1980. Mortality rates of common dolphin by stock and by individual fishery are not available. Seven *D. delphis* were observed taken in the shark drift gill net fishery in the 1985-86 season (Diamond et al. 1987), 3 in the 1984-85 season (Hanan 1986b), and none were observed taken in the three previous seasons. The movement of this fishery into more offshore waters over the past two years probably is responsible for the increase in observed take. Judging from the location of the fishery, the individuals taken are likely to be from the northern temperate stock.

Five *D. delphis* were observed taken in the southern California white sea bass fishery in 1983 (Collins et al. 1984) and one in 1985 (Collins et al. 1986). This fishery is primarily conducted in nearshore waters (depths of 20 fathoms or less; within 2.0 nm) in the Channel Islands and along the Los Angeles-Orange County portions of the SCB and somewhat further offshore southern San Diego County. Given the distribution of fishing effort, it seems likely that the incidental take of common dolphins observed in this fishery is from the "Baja neritic" stock.

A single *D. delphis* was observed taken in the halibut fishery in southern California in both 1983 and 1984 (Collins et al. 1984; 1985). This fishery operates primarily January - June in waters of 30 fm or less throughout a broad region of the SCB. There is no indication of which stock(s) are taken. One common dolphin was observed taken in the soupfin shark fishery in southern California in 1984 (Collins et al. 1984). The fishery operates over a somewhat broader range (2.1 - 5.0 km from shore) than other SCB fisheries.

Occasional strandings (ca. 2-3/yr) of common dolphins along the southern Orange and northern San Diego county coasts that are identified to be the result of fishery interactions (NMFS, Southwest Region files) most likely are associated with either the white sea bass set net or anchovy round-haul fisheries. At this date the stock affiliation of these individuals has not been determined, although some have been collected and retained by local museums. Walker (1975) noted that 22 *D. delphis* were collected for public display from the SCB between 1966-73.

Optimum Sustainable Population (OSP) and Effect of Incidental Take on OSP

In general, the level of incidental taking of common dolphins from either of the two stocks off California appears to be relatively limited. Specimens that would allow assignment of the kill to an individual stock have not been collected, although the nature of certain fisheries does allow for informed speculation concerning likelihood of the stock taken. Incidental mortality in the bonito fishery probably occurs among animals belonging to the larger offshore stocks. Incidental mortality in other components of the California seine and gillnet fisheries is likely to involve both the "Baja neritic" and "northern temperate" stocks.

Because population estimates by stock do not exist and because the information on incidental mortality is based on observation of only a very small portion (often < 1.0 %) of the effort expended in a fishery, the impact of incidental mortality on individual stocks cannot be assessed at this time.

Research Needs

Determine the size of the population and stock(s). Conduct aerial and ship surveys over entire ranges to estimate density and size of schools.

Continue to monitor the rate of incidental take and assign taking to appropriate population/stock. In particular, increasing the observer effort for the offshore shark gill net fishery is a high priority. Collect data on incidental take in fisheries, retrieve specimen material to determine stock and age and sex composition of the take; examine beached carcasses to determine cause of death.

Review the species and stock distinctions. Examine material in museum collections, collect new and examine curated photographic materials for color patterns.

Determine stock distribution and seasonal movement patterns. Monitor radiotagged animals, examine distribution of sightings by season, and analyze data from beached carcasses.

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Common Dolphin *Delphinus delphis* (Atlantic)

Stock Definition

This species is widely distributed in the temperate to tropical waters of the western North Atlantic and ranges from Iceland to the Venezuelan coast (Leatherwood et al. 1976).

Distribution

In the waters off the northeastern U.S. common dolphins are distributed in broad bands along the continental slope (100-2000 m) (CeTAP 1982; Selzer and Payne 1988). From mid-January to May they are widespread from Cape Hatteras northeast to Georges Bank (35°N to 42°N) in mid-to outer shelf waters (Hain et al. 1981; CeTAP 1982; Payne et al. 1984). From mid-summer to autumn common dolphins move northward onto Georges Bank and the Scotian Shelf. Selzer and Payne (1988) reported very large aggregations (>3,000 animals) on Georges Bank in autumn. Common dolphins are uncommon in the Gulf of Maine where temperature and salinity regimes are lower than on the slope of the Georges Bank/mid-Atlantic region (Selzer and Payne 1988). This distribution closely resembles that of squid, their primary prey.

Population Estimates

Common dolphins are one of the most abundant small cetaceans seen on the mid-shelf to slope waters off the northeastern U.S. (CeTAP 1982; Payne et al. 1984). The total number of common dolphins off the northeast U.S. coast is not known, but seasonal abundance and density estimates are available from two sighting survey programs conducted in the shelf water between Cape Hatteras, North Carolina and Nova Scotia. A primarily aerial survey program (CeTAP) was conducted from 1978 to 1982 (CeTAP 1982); an exclusively shipboard program (New England Sighting Survey program, NESSP) has been conducted since 1980 (Payne et al. 1984). Abundance estimates based on these data sets have been on the order of 31,100 to 34,300 animals, but have very high degrees of uncertainty (e.g., standard deviations of the estimates equal the estimates themselves). Additionally, data analysis procedures have improved since these estimates were made. CeTAP abundance estimates were highest in autumn and winter, whereas NESSP estimates were highest in spring. This may be attributable to differences in seasonal/spatial sampling effort.

Incidental Take in Fishery Operations

NMFS Foreign Fishery Observers reported 199 takes of common dolphins incidental to fishing activities in the shelf and slope waters off the northeast U.S. between March 1977 and April 1988 (Waring et al. 1988). One hundred and twenty three common dolphins

(62% of the total number captured between 1977-1988) were caught in the *Loligo* fishery. Since 1987, there are no reported takes in this fishery because all directed foreign *Loligo* fishing operations have ended. About 20 animals have been taken annually from 1986-1988 incidental to Atlantic mackerel fishing operations.

The incidental kill level in U.S. domestic fisheries is little known. Fifteen animals were observed dead in fishing nets transferred at sea from domestic vessels to foreign trawlers in joint venture operations, but the extent to which these observations are representative of U.S. incidental kill levels is unknown. The extent of fishing activity in Canadian waters that may involve the incidental take of common dolphins has not been determined.

Optimum Sustainable Population (OSP)

No OSP estimate has been developed for this population.

Effect of Incidental Take on OSP

The effect of incidental mortality on common dolphin OSP is unknown. The size/sex composition of the animals killed in commercial fishing operations indicates that most of the common dolphins were either sexually immature or inactive (Waring et al. 1988). Several species, including common dolphins, travel in herds segregated by age and sex. Incidental take of younger animals may be less significant to the health of the population than a take of sexually mature males or females.

Research Needs

To evaluate the status of the common dolphin population in this region and the effects of the current levels of incidental take, several additional research activities are needed.

Determine the population structure of the common dolphin and the effects of the current level of incidental take.

Define seasonal movement between U.S. and Canadian waters, determine the extent of Canadian fishing operations, and possible levels of incidental kill, and evaluate the reliability of earlier sightings data and population assessments from Canadian waters.

Continue to determine the age and reproductive condition (in addition to the size and sex composition) of animals taken in fishing operations in U.S. waters.

Apply recent improved analytic techniques for cetacean sighting survey data to evaluate the reliability of abundance estimates based on CeTAP and NESSP data.

Determine the affects of changes in squid distribution and abundance on common dolphin distribution by simultaneous analysis of sightings data from the NESSP and trawl survey and oceanographic data collected during the same cruises.

Determine the effects of dumping activity at the 106-Mile dumpsite on dolphins via their prey (squid) and bioaccumulation analysis of tissue specimens.

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Pacific white-sided dolphin *Lagenorhynchus obliquidens*

Stock Definition

The Pacific white-sided dolphin, *Lagenorhynchus obliquidens* is a North Pacific endemic first described by Gill (1865). The northwestern Pacific species, *L. ognevi* (Sleptsov 1955) is now thought to be invalid based on studies of morphological variation. Tomilin (1967) placed it in the synonyms list of *L. obliquidens*; it may represent a differentiated geographical population of animals with relatively long rostra.

Walker et al. (1986) concluded that two populations of *L. obliquidens* are present in the northeastern Pacific based on age, length, reproductive data, and cranial size. They found the southern form to be larger overall than the northern form. Analyses were somewhat hampered by a small sample size and an overlap in the distribution of the two populations in the southern California Bight (SCB).

Distribution

The Pacific white-sided dolphin is found throughout the temperate northern North Pacific Ocean from the coasts of Japan and Baja California, Mexico northward. It occurs year-round off California, Oregon, and Washington and in the waters of Alaska and Kurile Islands during the summer, but has not been reported from the Bering Sea or to regularly enter Prince William Sound. *L. obliquidens* frequents the continental shelf and slope, but on occasion has been sighted in large schools in offshore waters (Leatherwood et al. 1984).

Seasonal fluctuations or shifts in the distribution of population groups within this broad range may occur; however, the picture presented by recent studies is not clear, perhaps due to the effects of the recent El Niño event. Leatherwood et al. (1984) reported movement into waters north of 40°N in spring and summer and into waters between 23-30°N in the fall. However, Dohl et al. (1983) found that the largest numbers of *L. obliquidens*, in California waters north of Point Conception, occur in the fall. The species occurs year-round in southern California and off Baja California, Mexico. Leatherwood et al. (1984) identified a November to April increase in SCB numbers. Increases in *L. obliquidens* off Baja California and in the Sea of Cortez (Aurioles et al. 1988) were noted during late spring to early fall. There is a circumstantial, untested relationship concerning possible seasonal movement of animals from the SCB to Baja California waters. The distribution of the two morphologically distinct populations (a northern temperate form and a southern temperate form) apparently overlaps in the SCB

during winter periods. This concurrent distribution has confounded studies of population stocks.

Population Estimates

This dolphin is reported to be the second most abundant cetacean off southern California (Dohl et al. 1980) and the most abundant cetacean off northern California (Dohl et al. 1983). However, existing survey effort has been inadequate or inconsistent and does not allow us to calculate population estimates (Leatherwood et al. 1984). In connection with assessing impacts of tropical tuna seining operations on populations of marine mammals, and based on relative indices of sightings, Fox (1977) estimated that about 25,000 white-sided dolphins exist in an area of 1,535,870 sq km off southern California and Baja California bounded by about 122°W on the west, the continent on the east, 30°N on the north and about 20°N on the south. Dohl et al. (1980) presented an average (over all months) of approximately 9,300 animals for the SCB. Estimated seasonal abundance of *L. obliquidens* between Point Conception and the Oregon border are: spring 26,000; summer 32,000; autumn 86,000; and winter 33,500 (Dohl et al. 1983).

Incidental Take in Fishery Operations

Fox (1977) estimated the incidental kill of white-sided dolphins in the tropical tuna and wetfish seine fisheries for bluefin tuna and bonito at 29 per year. Other observed incidental mortalities of *L. obliquidens* include: one taken in a white sea bass net in 1985 (Collins et al. 1986), one taken in a flounder net near the Russian River in 1985 (Wild 1986), one taken in a drift gillnet in 1981 (Hanan 1986), and an unspecified number documented in the shark gillnet and trawl fisheries off the west coast (NMFS/NWR unpubl. data). Walker et al. (1986) stated that *L. obliquidens* "are sometimes caught incidentally in anchovy purse-seine operations, set in daylight and darkness" in the SCB; however, no numbers were provided. No estimates of the total incidental take in these fisheries are available. In addition to incidental kills, a few individuals have been captured for public display.

Optimum Sustainable Population (OSP) and Effect of Incidental Take on OSP

OSP has not been estimated for the population(s) of this species. Fox (1977) estimated that average incidental mortality in seines set for blue fin tuna and bonito off California and Baja California amounts to only about 0.1 percent of the population(s) and probably has "no impact on the existing or optimum sustainable population" of the region. Considering the small number observed taken in studies of all California fisheries since 1980 and the apparent large population, it is likely that the population(s) are at or

near carrying capacity and thus well above the lower bound of optimum sustainable population.

Research Needs

Determine the geographic range and seasonal movement patterns of the two population stocks. Determine if Pacific stocks include or are distinct from the population(s) of the mid-Pacific and Japanese waters. Carry out comparative morphological studies of materials presently available in museums, and continue to collect and analyze sighting data.

Determine population sizes. Carry out ship and aerial surveys to estimate density and size of schools throughout range of stock(s).

Continue to monitor the number of individuals taken annually in commercial fishing operations. Collect data on incidental take in fisheries and examine beached carcasses to determine cause of death.

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White-sided dolphin *Lagenorhynchus acutus* (Atlantic)

Stock Definition

The white-sided dolphin is one of three odontocetes that inhabits the continental shelf shoreward of the 100 m depth contour (CeTAP 1982). The species' range in the Western North Atlantic extends from southern Greenland south to the Mid-Atlantic Bight near Chesapeake Bay (Testaverde and Mead 1980). There are no data to support any separate stocks within the species.

Distribution

Sighting data suggest that Atlantic white-sided dolphins are distributed over the western Gulf of Maine, east and southeast of Cape Cod, and over Georges Bank in spring, summer, and fall (CeTAP 1982). In the winter, the animals appear to be less widely distributed in the shelf region; and sightings are made primarily in the Gulf of Maine and Cape Cod area (CeTAP 1982). The lower densities observed in winter suggest a general movement of Atlantic white-sided dolphins to offshore waters.

The distribution of Atlantic white-sided dolphin calves and juveniles appears to differ from adults. Calves and juveniles are found from the Gulf of Maine south to the Great South Channel but are rarely seen in the southern portion of the adult range (CeTAP 1982). Seltzer and Payne (1988) suggest that white-sided dolphin densities in the northeast region are highest in the Gulf of Maine because of their preference for cooler water temperatures.

Population Estimates

While the total number of whitesided dolphins off the northeast U.S. coast is unknown, seasonal abundance and density estimates are available from two sighting survey programs conducted in the shelf waters between Cape Hatteras, North Carolina and Nova Scotia. A primarily aerial survey program (CeTAP) was conducted from 1978 to 1982 (CeTAP 1982); an exclusively shipboard program (New England Sighting Survey Program, NESSP) has been conducted since 1980 (Payne et al 1984). Abundance estimates based on these data are about 35,000 to 45,000 animals, but have high degrees of uncertainty (e.g., standard deviations of the estimates equal to the estimates themselves). Additionally, data analysis procedures have improved since these estimates were made. From both data sets, abundance appears to be highest in the autumn and spring, and lowest in the winter.

Incidental Take in Fishery Operations

NMFS foreign fishery observers have reported 13 takes of white-sided dolphins incidental to fishing activities in the shelf

and slope waters off the northeast U.S. between March 1977 and April 1988 (Waring et al. 1988). Eight of 13 animals taken were captured in 1988 in the Atlantic mackerel fishery. The significant increase in the number of takes in 1988 may reflect an increase in fishing effort and expansion of the fishing regions.

Optimum Sustainable Population (OSP)

No OSP estimate has been developed for this population.

Effect of Incidental Take on OSP

The effects of the incidental kills are not precisely known, but are likely to be negligible because the level of kill is small relative to likely abundance levels.

Research Needs

Several additional research activities need to be undertaken to evaluate the status of the Atlantic white-sided dolphin and the effects of the current levels of incidental take, including: (1) Determination of seasonal movements and population structure of Atlantic white sided dolphins in the Northeast region; (2) Application of recent improved analytic techniques for cetacean sighting survey data to evaluate the reliability of abundance estimates based on CeTAP and NESSP data; (3) Identification and evaluation of sightings data for this species that may have been collected in other research programs in the region, for developing indices of abundance over time; (4) Determination of the size and sex structure, and age and reproductive condition, of the animals taken in the fishery.

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Northern right whale dolphin *Lissodelphis borealis*

Stock Definition

The northern right whale dolphin is the only small odontocete in the North Pacific Ocean without a dorsal fin. Two subspecies of *L. borealis* were identified by Nishiwaki (1972): *L. b. albiventris* and *L. b. borealis*. The distinction between subspecies was based on color pattern and dental formula. Leatherwood and Walker (1982) presented new evidence of variation in these characters which led them to conclude that there is insufficient evidence to differentiate *L. borealis* at the subspecific level.

Dohl et al. (1983) noted that there was a gap in the distribution of *L. borealis* along the California coast. Such separation could lead to the establishment of regionally distinct stocks if intermixing were not occurring; however, Dohl et al. noted that this exchange could be happening in poorly sampled offshore areas. Only a few specimens of *L. borealis* have been collected from the eastern North Pacific; thus, there has been insufficient material available to assess stock discreteness based on variation of color pattern or meristics. Given the absence of these types of data, an evaluation can not be made concerning the presence or absence of stocks for L. borealis.

Distribution

Northern right whale dolphins may occur in two disjunct "population centers" in the North Pacific, generally restricted to offshore temperate waters (Leatherwood and Walker 1982). In Japan, the species occurs along the Pacific coast from about 35° to 51°N with numbers generally fading E.N.E. (Nishiwaki 1966). There are no records from the Bering Sea, through the Aleutian Islands, and into the Gulf of Alaska. In the eastern North Pacific, *L. borealis* is found primarily off northern and central California, although records exist of sightings as far north as British Columbia (about 50°N; Pike and McAskie 1969) and nearly as far south as 30°N (Leatherwood and Walker 1982).

In the eastern North Pacific, the distribution of *L. borealis* may shift north or southward in conjunction with water temperature and prey availability. For example, the presence of increased numbers of *L. borealis* in the Southern California Bight (SCB) has been correlated with seasonally occurring cool water (winter and spring) or during long-term cooling trends (non-El Niño years; Leatherwood and Walker 1982). Interestingly, a winter increase in numbers occurs simultaneously in both central and southern California regions. Dohl et al. (1983) speculated that this increase is due to an influx of widely dispersed individuals from a poorly surveyed

region far offshore in the California current zone. The species uses nearshore waters between Point Piedras Blancas and Point Pi˜nos as a calving ground in winter (Dohl et al. 1983).

Winter increases of *L. borealis* off the Big Sur coast are thought to be related to the availability of Pacific whiting (*Merruccius productus*). In the SCB, *L. borealis* has been observed frequently around banks and seamounts which are centers of a variety of fishing activities, in particular for squid.

Population Estimates

The total world population of *L. borealis* is unknown. Nishiwaki (1972) estimated that the population size is over 10,000. Leatherwood and Walker (1982) considered this overly conservative and estimated on the basis of density statistics that the population in southern California is 17,800. Dohl et al. (1980) calculated a figure of 20,425 for this same region. Dohl et al. (1983) estimated that the population offshore northern and central California ranges from 27,000 in summer to 61,500 in winter. Combining the peak estimates from Dohl et al. (1980 and 1983) gives 81,925 for the California coast.

Incidental Take in Fishery Operations

Diamond et al. (1987) reported the take of one pregnant *L. borealis* in a shark drift gill net southeast of the San Juan Seamount (about 120 nm west of San Diego). Given the expansion of this fishery into the central California and offshore regions, which are occupied by *L. borealis*, and the lack of observer data for these fisheries, it is possible that additional individuals of this species are being taken but have not been reported or documented. One incidental mortality was reported by driftnet fishermen to NMFS' Northwest Region in January 1988.

Optimum Sustainable Population (OSP) and the Effect of Incidental Take on OSP

OSP has not been estimated for this species. Considering the small number taken, it is likely that the population remains at or near carrying capacity, i.e., above the lower bound of OSP.

Research Needs

Given color pattern variants and the disjunct distribution off central and northern California, it should be determined if more than one stock exists. Carry out comparative morphological studies of materials presently available in museums, and analyze sighting data.

Refine estimates of population size. Conduct ship and aerial surveys to estimate density and size of schools, in particular for the offshore California current region.

Assess movements and seasonal distribution, in particular, determine the extent of intermixing between disjunct groups of *L. borealis* and the source of the range-wide seasonal population increase.

Monitor annual take in commercial fishing operations, in particular the winter season of the southern California offshore and the central California components of the shark drift gill net fishery.

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Short-finned pilot whale *Globicephala macrorhynchus* (Pacific)

Stock Definition

Nishiwaki (1972) identified *Globicephala scammoni* as the Pacific pilot whale found only in the North Pacific Ocean. He identified *G. macrorhyncha* as a warmer water pilot whale in the Pacific and Indian Oceans. Rice (1977) identified only two species of pilot whales, *G. melaena* in the North Atlantic and southern oceans, and *G. macrorhynchus* found in the tropical and warm temperate waters of the Atlantic, Indian, and Pacific Oceans. The distinction between species is based primarily on skull morphology (van Bree 1971; Kasuya 1975; Polisini 1980). We use the later differentiation of *G. macrorhynchus* in this report.
Dohl et al. (1983) raised the possibility that three stocks of *G. macrorhynchus* might be present in the Pacific Basin based on the discontinuous distribution of the species. Presumably these stocks would include an eastern tropical Pacific group, a California group (ranging as far north as the Gulf of Alaska), and a Pacific Rim group (Aleutians to Japan).

Evans and Yablokov (1983) hypothesized that there may be two forms of this species off California, an "in-shore, resident" and an "off-shore, migrant" form based on observed differences in color pattern. However, a preliminary analysis of these characters and pod vocalizations did not support identification of separate stocks (Evans et al. 1984).

Distribution

In the North Pacific Ocean, *G. macrorhynchus* is found from Japan and the Aleutian Islands to probably Peru. It is an oceanic species with a very wide range (Leatherwood et al. 1982). Schools of pilot whales appear regularly off the western United States coast. It generally favors offshore waters, but often moves closer to land in search of food (Reilly 1977). Greatest numbers are seen in the eastern North Pacific Ocean in winter, fewer in summer (Dohl et al. 1980; 1983).

Reilly (1977) found that the greatest concentration of pilot whales in the eastern North Pacific during 1974-76 was from Pt. Conception, CA, to the Mexican border, although there were sightings as far north as San Francisco Bay. Until recently, *G. macrorhynchus* was seen regularly throughout the year only off California, especially in the Santa Catalina Channel. Seasonal abundance and distribution in this region seemed to be correlated with the inshore spawning migration of squid (primarily *Loligo opalescens*) and the appearance of other prey items, usually October through March (Hui 1985; Leatherwood and Dahlheim 1978). Surveys of the Southern California Bight (SCB) conducted during 1975-78 found a small group of 400 animals to be present year- round and a

winter increase possibly as high as 2,000 animals (Dohl et al. 1980). Pilot whale distribution changed during the 1982-84 El Niño warming event. Since late 1983, only small numbers of pilot whales have been sighted in the SCB (Shane 1984, 1986; Oliver and Jackson 1987), despite water temperatures having returned to normal. Shane (1987) has speculated that *Grampus griseus* has replaced pilot whales in the SCB, perhaps through interspecific aggressive behavior.

Surveys conducted in central and northern California from 1980-83 found only a few pilot whales. Sightings primarily were made in the Point Conception area and offshore in deep water. Dohl et al. (1983) raised the point that it is unknown where pilot whales from the SCB reside during periods of warm water or poor squid spawning seasons.

Population Estimates

The total population of the short-finned pilot whale is unknown. Sighting records from around Santa Catalina Island, California as early as 1921 and as late as 1981 indicate a range of 100-400 animals are likely present during the period of peak concentrations in that area (Dohl et al. 1980; Miller et al. 1983; Shane 1984).

Incidental Take In Fishery Operations

The only recorded information on pilot whale/fishery interactions on the west coast include: two incidents of pilot whales caught in purse seines in 1975, an incident involving squid seiners and approximately 8 to 10 pilot whale mortalities in 1977 near Malibu, one pilot whale entangled in a gillnet but released alive in Los Angeles Harbor in January 1979 (NMFS, SWR, Terminal Island files), two animals taken in 1980 in a shark drift gill net (Miller et al. 1983), and the mortality of 6 animals most likely associated with a squid purse seine on the windward side of Catalina in 1980. This does not account for those animals caught and released or harassed during fishing operations, or those animals that may be killed during fishing and not reported or recorded.

Miller et al. (1983) estimated that in 1980 a maximum of 30 pilot whales were taken annually in the southern California squid fishery and 30 pilot whales were taken annually in the shark drift gill net fishery.

Optimum Sustainable Population (OSP) and the Effect of Incidental Take on OSP

The lack of accurate population and stock discreteness data make identification of optimum levels impossible. This lack of information further complicates any assessment of impact of incidental take on the species or stock. For example, if pilot

whales return to the SCB, and the previously reported mortality level for pilot whales in this area continues, the level of take would not seriously affect the pilot whale population if it was spread throughout a large, widely ranging, single stock; however, the take may be significant if the population is composed of several small stocks.

Research Needs

Identification of stocks, ranges, and distribution. Conduct additional studies of morphology, meristics, color patterns, and vocalizations.

Estimation of population and (if applicable) stock sizes. Aerial and shipboard surveys.

Continue and improve monitoring of incidental take in the various fisheries.

Development of life history information, i.e., natural mortality and natality rates, age at sexual maturity, etc. Use of incidentally taken and stranded animals.

Development of natural history information, i.e., social behavior, migration routes, feeding habits, foraging habitat, etc. Conduct photo-identification and telemetry studies.

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Pilot Whale *Globicephala* spp. (Atlantic)

Stock Definition

There are two species of pilot whales in the western North Atlantic. *G. melas*, (Atlantic pilot whale) is the northernmost species distributed from Iceland to North Carolina, whereas *G. macrorhynchus*, (short-finned pilot whale) ranges from Virginia to the Venezuelan coast (Leatherwood et al. 1976). The area of overlap between the two species is between the Delmarva Peninsula and Cape Hatteras (CeTAP 1982). *G. melas* is the species of principal concern off the northeast U.S. coast. Stock or population structure of both species is unknown.

Distribution

Atlantic pilot whales are concentrated along the shelf edge of mid-Atlantic and southern New England waters between the 100m and 1000m contour during mid-winter and spring (Waring et al. 1988). Areas of pilot whale concentration in more northerly waters during this period have not been reported. Throughout spring and early summer, there is an increase in the number of sightings along the shelf edge from the mid-Atlantic region northward to inshore Newfoundland waters (Sergeant et al. 1970; Mitchell 1975). Pilot whale distribution is widespread over the shelf waters off the northeast U.S. and more northerly waters during late summer and autumn.

A satellite tagged Atlantic pilot whale was released in June 1987 in central Georges Bank. It was observed to move first to the south, and then across the Bank to the north where it ranged generally east to west into late summer (B. Mate pers. comm.). These movements presumably relate to prey abundance as the observed diving sequences were suggestive of feeding behavior. Sightings of pilot whales off Newfoundland appeared to be related to *Illex* squid abundance (Sergeant et al. 1970). However, observations of pilot whale feeding and foraging behavior off southern New England in recent years indicate a distribution more closely tied to Atlantic mackerel (*Scomber scombrus*)(Waring et al. 1988).

Population Estimates

Estimates of the total number of short-finned pilot whales are not available. Estimates of abundance for the Atlantic pilot whale for its entire range are also not available. Estimates of abundance, based on data from a directed fishery in Newfoundland from 1952-1972, were on the order of 50-60,000 (Mitchell 1975; Mercer 1975). During this period, a decline in the abundance of pilot whales was observed, although a decline in the *Illex* squid fishery was observed coincidentally in that region (Mercer 1975). Seasonal abundance and density estimates are available from two sighting survey programs conducted in the shelf waters between Cape

Hatteras, North Carolina and Nova Scotia. A primarily aerial survey program (CeTAP) was conducted from 1978 to 1982 (CeTAP 1982); an exclusively shipboard program (New England Sighting Survey Program, NESSP) has been conducted since 1980 (Payne et al. 1984). Because species separation can not easily be done in the field, these data include an unknown proportion of short-finned pilot whales in the area of overlap. Abundance estimates based on these data sets have been on the order of 12,000 animals, but have high degrees of uncertainty. For both data sets, abundance estimates are highest in autumn and spring and lowest in winter.

Incidental Take in Fishery Operations

NMFS observers aboard foreign fishery vessels reported 296 takes of pilot whales incidental to fishing activities in the shelf and slope waters off the northeast U.S. between March 1977 and April 1988 (Waring et al. 1988). The majority of these takes were either in the Atlantic mackerel (251, 85.0%) or the *Loligo* squid (28, 9.5%) fisheries. The total number and percentage of pilot whales caught in the *Illex* squid fishery was small (3, <1%). Since 1984, 93% of the takes were in the mackerel fishery. In addition, the 1988 take (n= 141) greatly exceeded the 1987 (n= 26) and 1986 (n= 20) levels. The reason for this increase in the number of animals killed is not known, but the numbers killed per day of fishing increased for all fleets in 1988. The number of vessels fishing in these waters also increased this year, possibly involving captains with less fishing experience. However, there may have also been changes in fishing conditions or in the behavior of the animals. These factors, and thus the reasons for the increased 1988 take, remain unknown.

Incidental kill levels in U.S. domestic fisheries are little known. Animals have been observed dead in nets from U.S. vessels transferred at sea to foreign trawlers in joint venture operations. The extent to which these observations are representative of U.S. incidental kill levels is unknown. Similar fishing activity in Canadian waters that may involve the incidental take of pilot whales has not been quantified.

Optimum Sustainable Population (OSP)

No OSP estimate has been developed for this population.

Effect of Incidental Take on OSP

The impact of current incidental mortality levels on the population is unknown. Present levels are comparable to recent mass strandings in New England waters (G. Early pers. comm., NEA) that are considered to be part of the natural mortality for the species. However, it is well below the mortalities reported by Mercer (1975) for the historical Newfoundland drive fisheries (1948-1971: Total -

54,248; Average - 2,260/yr), during which a decline in numbers was observed.

The size/sex composition of the animals killed in commercial fishing operations indicates that most of the pilot whales were sexually mature females. The data are similar to size/sex ratios observed in mass stranding in New England waters (Early pers. comm.). Pilot whales are gregarious and social groupings are believed to be comprised of several sexually mature females and a few mature males (Early pers. comm.) The effect of the concentration of the incidental catch on the reproductively more valuable mature female component of the population is not known.

Research Needs

Several additional research activities need to be undertaken to evaluate the status of the pilot whale populations in this region and the effects of the current levels of incidental take:
1. Determine the seasonal movements and population structure of the Atlantic pilot whale; 2. Determine the extent of incidental take in Canadian fishing operations, and evaluate the reliability of earlier sightings data and population assessments from Canadian waters; 3. Determine the age, reproductive condition and feeding habits (in addition to the size and sex composition) of animals taken in fishing operations in U.S. waters, including information on effects of the presence of biotoxins in mackerel, the principle diet item; 4. Apply recent improved analytic techniques for cetacean sighting survey data to evaluate the reliability of abundance estimates based on CeTAP and NESSP data; 5. Evaluate existing data from a single satellite tagged pilot whale to determine relationship of movement pattern to prey abundance and oceanographic conditions, and develop protocol for future use of such tools; 6. Determine the effects of changes in finfish and squid distribution and abundance on pilot whale distribution by simultaneous analysis of sightings data from the NESSP and trawl survey and oceanographic data collected during the same cruises.

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Grampus (Risso's Dolphin) *Grampus griseus* (Atlantic)

Stock Definition

The Grampus (Risso's dolphin) has a worldwide distribution in both tropical and temperate seas. There is no information on stock differentiation.

Distribution

Grampus are distributed in the western North Atlantic from eastern Newfoundland, south at least to St. Vincent, Lesser Antilles, and in the eastern and northern Gulf of Mexico (Leatherwood et al. 1976).

On the northeast U.S. coast, *Grampus* are distributed along the shelf edge from Cape Hatteras northward to Georges Bank during the spring, summer and autumn (CeTAP 1982; Payne et al. 1984). In winter, the northern extension of its range begins at the Mid-Atlantic Bight and extends more offshore (>100m) (Payne et al. 1984). In general, the population of *Grampus* in the northeast region occupies the Mid-Atlantic shelf edge area year round, and is usually absent from the Gulf of Maine (Payne et al. 1984).

Population Estimates

The total number of *Grampus* off the northeast U.S. coast is not known, but the seasonal abundance and density estimates are available from two sighting survey programs conducted in the shelf waters between Cape Hatteras, North Carolina and Nova Scotia. A primarily aerial survey program (CeTAP) was conducted from 1978 to 1982 (CETAP 1982); an exclusively shipboard program (New England Sighting Survey Program, NESSP) has been conducted since 1980 (Payne et al. 1984). Abundance estimates based on these data sets have been on the order of 5,500 to 11,500 animals, but have high degrees of uncertainty (e.g., standard deviations of the estimates equal to the estimates themselves). Additionally, data analysis procedures have improved since these estimates were made. From both data sets, abundance appears to be highest in the spring and summer and lowest in the winter.

Incidental Take in Fishery Operations

NMFS foreign fishery observers have reported the take of 4 *Grampus* incidental to fishing activities in the shelf and slope waters off the Northeast U.S. between March 1977 and April 1988 (Waring et al. 1988). However, no *Grampus* were reported taken prior to 1985. Three of 4 animals were captured in the squid fisheries; one animals was taken in tuna longline gear. These takes were associated with both the *Loligo* and *Illex* squid fisheries. Given that the *Grampus* feeds almost exclusively on

squid (Nishiwaki, 1972) it is understandable that their incidental take has been mostly limited to this fishery.

Optimum Sustainable Population (OSP)

No OSP estimate has been developed for this population.

Effect of Incidental Take on OSP

The effect of incidental mortality is unknown, but is believed to be negligible. Levels of take are low relative to likely abundance levels.

Research Needs

Several additional research activities need to be undertaken to evaluate the status of the *Grampus* dolphin in this region and the effects of the current levels of incidental take: 1. Determine seasonal movements and population structure of *Grampus* in the northeast region; 2. Apply recent improved analytic techniques for cetacean sighting survey data to evaluate the reliability of abundance estimates based on CeTAP and NESSP data; 3. Determine the size and sex structure, and age and reproductive condition of the animals taken in the fishery.

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Beluga (Belukha;white whale) *Delphinapterus leucas*

Stock Definition

Based on the potential for geographic isolation, observation of seasonal movement, and year-round residency, it has been suggested that beluga whales in Cook Inlet are distinct from other coastal and offshore groups (Sergeant and Brodie 1969). It also was suggested that the population of beluga whales in North American may be further divided into stocks based on summer distributions in Bristol/Kuskokwim Bays, Norton/Yukon Sound, Kotzebue Sound, Northwest Alaska and eastern Beaufort Sea (Braham 1984; Finley et al. 1987). There are no data to verify stock differentiation among *Delphinapterus leucas* in North American waters.

Distribution

Beluga whales are distributed circumglobally in arctic and subarctic waters (Yablokov et al. 1974) and are closely associated with open leads and polynya in ice covered regions north of 40°N latitude (Harrison and Hall 1978; Braham et al. 1984). Concentrations occur in both offshore and coastal regions and vary by season and region (Braham et al. 1984).

Factors affecting seasonal and daily distribution include ice cover, temperature, prey availability, tidal conditions, and human disturbance (Calkins 1984; Fraker et al. 1979; Frost et al. 1983b; Frost and Lowry 1984; Seaman et al. 1985). Generally, beluga whales occupy waters associated with offshore pack ice in winter, and migrate in spring to warmer (10-15°C) coastal estuaries, bays, and rivers for molting and calving.

Large concentrations of belugas, which are summering in coastal regions of the U.S., western Canadian Arctic, and the east coast of USSR, gather in offshore areas of the Bering Sea in winter (November - March; Finley et al. 1987). The majority of the U.S. population of beluga whales are associated with these winter gatherings, although year-round concentrations also occur in the Bering Strait, Chukchi Sea, Bristol Bay, and Cook Inlet in the Gulf of Alaska (Burns and Seaman 1985; Frost et al. 1983a).

Groups of belugas in the Bering Sea during winter migrate to North American and Soviet coastal regions in the spring (March-May), following open leads in the retreating pack ice (Braham et al. 1984). Although the majority of North American groups probably go to Banks Island and the Mackenzie River Delta (Harrison and Hall 1978) in the Eastern Beaufort Sea, some go to coastal regions of northwest Alaska, where they appear to be transients during pack ice periods in the eastern Chukchi Sea (Braham et al. 1984).

In U.S. waters during spring beluga whales are found in Cook Inlet, Bristol Bay, Norton Sound and the Yukon Delta, the Eastern Chukchi Sea (e.g., Kotzebue Sound), and transient groups traveling offshore on their way to the eastern Beaufort Sea (Braham et al. 1984; Finley et al. 1987; Fraker et al. 1979; Harrison and Hall 1978).

The duration of residence in summer areas varies, but most whales usually remain in densely concentrated pockets throughout the summer. In autumn (September-November) the greater portion of the population migrates to the Bering Sea ice edge for winter (Burns and Seaman 1985; Fraker et al. 1979; Harrison and Hall 1978).

Migration to coastal areas and river systems of northwest Alaska is coincident with the break-up of ice and the arrival of spawning fishes such as herring, capelin, and salmon. Beluga whales make use of tides in pursuit of prey upriver by ascending on the flood and descending with ebb tides. Animals have been sighted as far as 1000 km up the Yukon River (Seaman et al. 1985).

Population Estimates

In Alaska, Burns et al. (1985) estimated 13,500-18,000 individuals in the western Arctic and over 500 individuals in the Gulf of Alaska. Approximately 5,000 belugas were counted in the Mackenzie Delta during July, 1974 (Sergeant and Hoek 1974). In winter, an estimated 1,100 are found in Bristol Bay (Frost et al. 1983a), near the Pribilof Islands, and in Norton Sound (Harrison and Hall 1978).

There are at least 40-55,000 belugas world-wide (Braham 1984). Between 15,800-18,450 are minimally estimated to summer in coastal waters of Alaska and western Canada (Hazard 1988); of these, only 300-500 are known to comprise the Cook Inlet population. Burns et al. (1985) estimated there were over 25,000 belugas in the western Arctic, after compensating for areas not surveyed, submerged animals during counts, and summering animals not counted off the USSR.

Approximately 26,500 belugas are found in the Canadian Arctic (Sergeant and Brodie 1975), which includes 6,300-18,600 individuals in Lancaster Sound and adjoining waterways (Smith et al. 1985), 500 in St. Lawrence estuary (Sergeant 1986), 8,940-10,000 in Hudson Bay and Hudson Strait (Sergeant and Brodie 1975; Finley et al. 1982), and 750 in Cumberland Sound and near Baffin Island (Sergeant and Brodie 1975).

Incidental Take in Fishery Operations and Harvest Levels

Most incidental kills of belugas probably occur in Bristol Bay where a large salmon fishery exists. In 1983, 27 belugas were found dead in Bristol Bay, 12 were caught in salmon gill nets (Frost et al. 1983a). Murray and Fay (1979) reported five belugas were taken annually in the salmon gillnet fishery in Cook Inlet.

Presently, only indigenous people are allowed to hunt belugas in Canada for subsistence purposes, and this accounts for most of beluga mortality (Finley et al. 1987). Approximately 130 to 150 belugas per year are killed by Inuits in the Mackenzie Delta, and possibly another 10 belugas are taken elsewhere in the Canadian Beaufort Sea (Sergeant and Brodie 1975).

Fewer belugas were killed for subsistence purposes in Alaska (average 150-500 per year) than in Canadian waters (Sergeant and Brodie 1975; Seaman and Burns 1981; Burns et al. 1985). While greatest catches were in the 1950s, presently an estimated 600-700 belugas per year are killed for subsistence purposes in the western Arctic, of which probably 100-200 belugas are killed in Soviet waters (Burns et al. 1985; Seaman and Burns 1981). Actual numbers of animals killed are unknown because approximately 60% of belugas killed in deep water are not recovered, whereas 20% are not recovered when killed in shallow water (Seaman and Burns 1981).

Optimum Sustainable Population (OSP)

Some populations of belugas in Alaska may be within optimum sustainable levels, but populations summering in Cumberland Sound, Baffin Island, and Ungava Bay, Canada, are probably depleted (Sergeant 1986).

Effect of Incidental Take and Harvesting on OSP

The number of belugas killed incidentally or harvested probably is not great enough to affect population levels of some stocks. Harvesting 450 belugas per year between 1948 and 1960 did not appear to visibly deplete the local population in Hudson Bay (Sergeant 1962). Presently the 300 belugas per year killed in the Beaufort Sea is within the sustainable limits of this population (Finley et al. 1987). Also, the number and distribution of belugas appear unaffected by incidental kills in the salmon fishery in Bristol Bay (Burns et al. 1985). However, under present harvest levels worldwide, an estimated 44% of the defined stocks are being exploited at or above suggested replacement yields (Braham 1984).

Research Needs

Studies to determine stock differentiation and distribution - especially the relationship between summer and winter groups are needed.

Population abundance and trends in abundance are needed.

Reproductive parameters and updated aging estimates are needed, for harvested stocks especially.

Inadequate information is available on food habits throughout the range is available and should be augmented.

Information on the effects of human disturbance, especially gillnet fishing, and noise needs to be studied.

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Minke Whale *Balaenoptera acutorostrata* (Atlantic)

Stock Definition

There are four recognized populations or stocks of minke whale in the North Atlantic Ocean: Canadian east coast stock, west Greenland stock, east Greenland-Iceland-Jan Mayen stock, and Svalbard-Norway-British Isles stock. These stock definitions are based on a variety of sources of information, including catch records and distribution of sightings. However, considerable uncertainty about them remains. Minke whales off the northeast coast of the U.S. are thought to be part of the Canadian east coast stock.

Distribution

Minke whales are distributed in the polar, temperate, and tropical waters of the western North Atlantic (Leatherwood et al. 1976). They are found from the pack ice south to at least Anguilla, Lesser Antilles, and the eastern Gulf of Mexico. Although they appear to be most abundant in temperate water north of 40°N and are reported infrequently from tropical waters (NMFS unpubl. data).

In spring and summer they range from Virginia to Baffin Island (Payne et al. 1984). They are most abundant off the northeast U.S. coast during these seasons, particularly from Block Island around Cape Cod to Jeffery's Ledge in the Gulf of Maine (CeTAP 1982). In autumn they are observed only in the nearshore Gulf of Maine waters (CeTAP 1982). Few animals are seen in the northeast region in winter, and their winter range is not known. Minke whales, like other baleen whales, tend to occupy the shelf proper rather than the shelf edge off the northeast U.S. coast (CeTAP 1982).

Population Estimates

A recent international North Atlantic sighting survey resulted in estimates of the size of at least portions of three of the stocks. No data were collected for the Canadian east coast stock, which extends from north of Newfoundland to the U.S. northeast coast. An aerial survey conducted in the Newfoundland and Labrador region in 1980 resulted in too few minke whale sightings to allow for reliable estimates of abundance. Seasonal abundance and density estimates are available from two sighting survey programs conducted in the shelf waters between Cape Hatteras, North Carolina and Nova Scotia that represents a small portion of the total stock's range. A primarily aerial survey program (CeTAP) was conducted from 1978 to 1982 (CeTAP 1982); an exclusively shipboard program (New England Sighting Survey Program, NESSP) has been conducted since 1980 (Payne et al. 1984). Abundance estimates based on these data sets have been on the order of 300 to 400 animals, but have high degrees of uncertainty (e.g. standard deviations of the estimates equal to

the estimates themselves). Additionally, data analysis procedures have improved since these estimates were made. From both data sets, abundance appears to be highest in the autumn and spring, and lowest in the winter.

Incidental Take in Fishery Operations

NMFS foreign fishery observers reported 1 take of a minke whale incidental to fishing activities in the shelf and slope waters off the northeast U.S. between March 1977 and April 1988 (Waring et al. 1988). The animal was taken in tuna longline gear and was released alive. No other incidental kills have been reported.

Optimum Sustainable Population (OSP)

No OSP estimate has been developed for this population.

Effect of Incidental Take on OSP

The effect of incidental mortality is unknown, but is likely to be negligible because recent levels of take are low relative to estimated abundance levels.

Research Needs

Several additional research activities need to be undertaken to evaluate the status of the minke whale stock in this region and the effects of the current levels of incidental take: 1. Determination of the level of other incidental takes of this stock, especially in fisheries off the Canadian Maritimes; 2. Determination of abundance of minke whales in the Canadian east coast stock, possibly by sighting surveys using methods being developed for other stocks in the North Atlantic; 3. Determination of the winter distribution of minke whales in the North Atlantic, and evaluation of relationships among the several stocks.

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Killer whale *Orcinus orca*

Stock Definition

The killer whale is the largest member of the family Delphinidae. Adults range in length from 5 to 9 meters. The large size, robust body, postocular white spot, and ovate flippers are diagnostic. Killer whales are one of the most strikingly pigmented cetaceans making field identification easy. Killer whales are black dorsally and white ventrally. Dorsal fin height can attain 1.8 meters in males, whereas in adult females and subadult males fin height is less than 0.9 m. Dorsal fin height is a useful character for distinguishing adult males within pods.

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and off-shore waters, killer whales prefer the colder waters of both hemispheres, with greatest abundance within 800 km of major continents (Mitchell 1975). In Alaska, whale concentrations are reported near land masses and continental shelf waters (Braham and Dahlheim 1982). Killer whales are common in the inland waterways of Alaska, British Columbia and Washington State. The genus *Orcinus* is currently considered monotypic with geographical variation noted in size and color pattern, but a worldwide systematic review is needed. Significant differences in call repertoires (Ford and Fisher 1982) and color patterns (Evans et al. 1982) of whales with overlapping ranges indicate some isolation among pods. Chromosomal and biochemical evidence suggests that certain pods may be genetically isolated (Duffield and Cornell 1979).

Distribution

Killer whales typically occur in small pods of fewer than 40 animals. Multipod gatherings have been noted, however the biological significance of these groupings is not known. Pod composition appears to remain constant through time with little intermixing of individuals among pods (Bigg 1982). Seasonal occurrence of killer whales is documented in some regions while in other areas killer whales are year-round residents. Killer whales occur off northwestern Alaska, the western Chukchi and Bering Strait, Bering Sea, and Aleutian Islands (Braham and Dahlheim 1982). In the Chukchi and northern Bering Seas, whales move south with the advancing pack ice and under these conditions long-range movements occur.

Areas of concentrations occur in Prince William Sound, and off Kodiak Island, the Aleutian Islands, and Southeast Alaska (Braham and Dahlheim 1982). Year-round occurrence has been documented for the intracoastal waterways of British Columbia and Washington State. Based on photo-identification techniques (identifying

whales by distinctive dorsal fins and saddle patch characteristics), population size and movements of killer whales have been investigated. Movements of whales have been documented between Prince William Sound (Alaska) and Southeast Alaska, as well as between Southeast Alaska and British Columbian waters. Resident whales (occurring in area on a year-round basis) typically have smaller home ranges than transient whales. Sporadic occurrence is noted for the coasts of Washington, Oregon and California. Killer whales occur from the Gulf of California more or less continuously along the Pacific Coast from 35°N to just below 5°S. Nearly all records off California and western Baja California were within 150 nm of the coast (Dahlheim et al. 1982).

Movements of whales are believed to be related to availability of prey (Mitchell 1975; Dahlheim 1981). Sergeant and Fisher (1957) believed movements off eastern Canada were associated with migrations of whales and seals. Reports from Japan (Nishiwaki and Handa 1958) indicate that primarily cod, flatfish, and cephalopods were taken and whale movements appeared to be related to movements in prey species. Daily food intake is unknown, though Mitchell (1975) estimated that killer whales need 4% of their body weight in fish per day.

Population Estimates

There is no estimate of worldwide abundance of killer whales. Population levels are not considered high by most authorities. Leatherwood et al. (1984) reported 286 killer whales in three areas within Alaska (Prince William Sound, Southeast Alaska and Shelikof Strait). Population estimates are not available for the Aleutian Island region or the Bering Sea, but are expected to be similar to levels reported for other Alaskan areas. In the inland waters of British Columbia and Washington State, 260 whales comprising 30 pods have been reported (Bigg 1982). Since killer whale sightings decrease significantly southward along the continental United States, a corresponding decline in the number of whales is assumed.

Incidental Take in Fishery Operations

Killer whales have never been subjected to significant rates of exploitation (Dahlheim 1981). Incidental takes during fishing operations are rare. Reports of fishery interactions involving the predation by killer whales on longline catches of sablefish *Anoplopoma fimbria*) have recently been documented in Alaskan waters. Reports of whale depredation on longline caught blackcod were documented in the southeastern Bering Sea and Prince William Sound areas. In Prince William Sound, a killer whale pod (consisting of 35 members) was identified as being responsible for the blackcod fishery interactions. This particular pod experienced a significant increase in mortality (Dahlheim 1988). Between 1985 and 1987, seven whales were listed as missing and presumed dead.

Based on information concerning life spans, the natural mortality rate of killer whales is estimated to be 5% per year for the total population; thus the loss of seven whales over a three year period is high. Mortality, if any, of killer whales in the Bering Sea associated with blackcod longline operations is unknown. Fishery interactions involving killer whales are not unique to Alaska. Off Iceland, killer whales were known to interfere with the herring fishery. In the 1950's, predatory control measures were employed off Iceland due to complaints about damage to fishing gear. Reports of killer whales preying on longline caught tuna are available for various areas (e.g., North Atlantic, coast of Japan, and Indian Ocean). Off Tasmania, killer whales were known to prey on trevalla (species of rockfish) caught in the drop-line fishery. Reports of incidental deaths of killer whales associated with the coastal fisheries off the coasts of the Washington, Oregon and California are uncommon. Foreign fisheries data indicate few killer whales are taken.

Optimum Sustainable Population (OSP)

There has been no directed exploitation of killer whales in the United States. Mortality associated with fishing operations is considered low, but more data are needed on the nature, level, and impacts of interactions between killer whales and longline fisheries in Alaska. During 1962-76, a live capture fishery was active in the local waters of Washington State and British Columbia. During this period, 302 whales had been captured, of which 10 died, 55 were kept for public display and 237 were released (Asper and Cornell 1977). Since 1976, no live capture attempts have taken place in this area. Effects of environmental pollutants are not known for cetaceans; however, Calambokidis et al. (1984) found high levels of PCBs and DDT in the tissues of killer whales from Washington State waters. Besides internal parasites and natural disease, killer whales have no significant predators other than man. If incidental take is insignificant, and assuming that no other factors (i.e., pollution, disease, decline in prey resources) are adversely affecting the population, then killer whale populations could be at OSP.

Effect of Incidental Take on OSP

Incidental mortality occurs during commercial fishing operations but the numbers of animals reported taken are low. However, given that as many as 7 whales from a single pod of 35 in Prince William Sound could have been killed by fishermen between 1985-87, and that the nature and level of incidental take in other areas is virtually unknown, it is possible that the effects of interactions on killer whales are significant.

Research Needs

More information is needed on the nature, level, and impacts of interactions between killer whales and longline fisheries in the Gulf of Alaska (including Prince William Sound) and the Bering Sea.

Additional research is needed to provide information on:

1. Changes in fishery practices or other measures that possibly could prevent or reduce interactions
2. Abundance estimates
3. Distribution/seasonal movements
4. Habitat characterization
5. Predator/prey relationships (to include food habits)
6. Reproductive/behavioral features
7. Stock differentiation
8. Effects of human related activities on killer whales (e.g., fisheries/oil-industry).

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Humpback whale *Megaptera novaeangliae* (Pacific)

Stock Definition

The humpback whale occurs in all of the world's oceans. Like most baleen whales, humpbacks annually migrate between high-latitude, summer feeding grounds and temperate or sub-tropical wintering grounds. Humpbacks are divided into 3 geographically and reproductively isolated populations in the Southern Hemisphere, the North Atlantic, and the North Pacific (Johnson and Wolman 1984).

The North Pacific humpback whale population has been divided tentatively into 3 stocks, based on the relative discreteness of wintering areas: the Mexican stock (Rice 1966), the Hawaiian stock (Wolman and Jurasz 1977; Baker and Herman 1981), and the Asian stock (Townsend 1935; Nishiwaki 1959). Limited exchange of whales between the Mexican and Hawaiian stocks has been documented (Darling and Jurasz 1983; Darling and McSweeney 1985), and whales from each of the 3 wintering areas have been linked to summer feeding grounds in Alaska (Johnson and Wolman 1984; Baker et al. 1986). While this designation of stocks may facilitate management of the whales in particular areas, the information on exchange between stocks and apparent mixing of stocks on the foraging grounds indicates that stocks may not be entirely distinct.

Distribution

The summer foraging range of the North Pacific humpback population includes coastal waters from Point Conception, California, around the Pacific rim to the Kamchatka Peninsula, USSR, and northward into the Bering and Chukchi Seas (Johnson and Wolman 1984).

Humpbacks occur throughout Alaskan waters, but tend to concentrate in several specific areas: 1) southeastern Alaska (Baker et al. 1985), 2) Prince William Sound and the central Gulf of Alaska (Hall 1979; Rice and Wolman 1982), 3) the western Gulf of Alaska near Kodiak Island (Rice and Wolman 1982; Leatherwood et al. 1983), 4) south of the Alaska Peninsula between the Shumagin and Semidi islands (Berzin and Rovnin 1966), and 5) the eastern Aleutian Island and Bering Sea (Berzin and Rovnin 1966; Rice 1978; Leatherwood et al. 1983).

Humpbacks primarily inhabit Alaska waters from late spring to early winter, approximately May through December. Peak numbers of whales in southeastern Alaska typically are seen in late August and September (Baker et al. 1985). Individual humpbacks may be seen in Alaska at any time of year, especially in southeastern Alaska, but there is no evidence to suggest that any of those individuals overwinter there (Baker et al. 1985).

Short-term seasonal distribution patterns have been documented in southeastern Alaska (Baker et al. 1985) and in Prince William Sound (Hall 1979; von Zeigesar 1984). This includes fairly predictable local movements, such as those among favored feeding areas in the vicinity of Glacier Bay, as well as more general regional movements, such as the late-summer influx of whales to the Fredrick Sound region of southeastern Alaska (Baker et al. 1985). This seasonal distribution of humpbacks on the feeding grounds is subject to annual variability due to changes in oceanographic conditions and/or distribution and availability of prey (Bryant et al. 1981; Kreiger and Wing 1984; Baker et al. 1985).

The summer distribution of humpback whales off California appears to be centered near the Farallon Islands. Results from recent studies suggest the possibility of a subpopulation that breeds in Mexico and forages in the vicinity of the Gulf of the Farallons (Dohl et al. 1983). The waters off southern California apparently are migration corridors. Humpbacks are seen seasonally off southern California in the fall and spring as they travel to and from their wintering grounds off Mexico. Most whales seem to be travelling along the Santa Rosa-Cortez Ridge although some whales may enter the more coastal waters of the San Pedro and Santa Barbara channels (Dohl et al. 1980; Schulman 1984).

Humpbacks occur seasonally off Oregon and Washington from spring through fall. During the whaling activities in Washington from 1913 to 1919, humpbacks were received at the Bay City whaling station from April through October, with the majority taken during June, July, and August (Scheffer and Slipp 1948). Sightings of humpbacks recorded by the NMFS National Marine Mammal Laboratory (NMML) Platforms of Opportunity Program are from every month except February, March, and April (Braham unpubl. data).

Humpbacks may appear in Hawaiian waters as early as October, but the season is more commonly thought to begin in December. Peak numbers typically occur in February (Herman et al. 1980). The earliest observable peak in whale numbers may occur near the Island of Hawaii, with the island to the northwest showing progressively later dates of peak residency (Baker and Herman 1981). The average duration of wintering residency in Hawaii is not known, although the maximal known stay for a cow/calf pair is 56 days (Glockner-Ferrari and Ferrari 1985).

In general, humpback whale distribution in Hawaii appears to be limited to waters within the 100 fathom isobath. The area of greatest use by humpbacks in Hawaii is the "four island area" (Maui, Molokai, Lanai, Kahoolawe) and Penguin Bank. The waters off Niihau and the Island of Hawaii, from Keahole Point north to Upolu Point also are used by humpbacks. Kaula Rock, just southwest of Niihau marks the approximate western limit of humpback distribution in Hawaii. Few whales have been observed around the atolls, island, banks, and reefs of the northwestern Hawaiian Islands. The

distribution of humpback whales in Hawaii appears to have remained fairly constant over time (Herman et al. 1980).

The distribution of humpbacks wintering in the western North Pacific is less well documented. Generally, humpbacks winter in the vicinity of the Mariana Islands, the Bonin Islands, the Ryukyu Islands, and Taiwan (Ivashin and Rovnin 1967; Johnson and Wolman 1984).

Population Estimates

The pre-exploitation (prior to 1905) population size of humpback whales in the North Pacific is not known, but estimates suggest that it may have been on the order of 15,000 whales (Rice 1978). There has been no sequence of surveys long enough or consistent enough to detect trends in abundance of whales since they were protected by the International Whaling Commission (IWC). It is not possible, therefore, to determine if the population is recovering under the current regime of protection.

Current estimates of population size range from about 1,200 (Rice and Wolman 1984) to over 2,000 (Darling 1983 in Leatherwood et al. 1983). More than 1,000 whales were identified in Hawaii from 1977 to 1982 (Darling and McSweeney 1985). Mark-recapture analyses based on photo-identification data have led to estimates that about 1,600 (Baker et al. 1986) to 2,100 (Darling and Morowits 1986) whales visited Hawaiian waters between the late 1970s and early 1980s. No good estimates are available for the number of whales on the other wintering grounds, but they may be as small as a few hundred in Mexico and less than 100 in the western Pacific (Johnson and Wolman 1984).

An estimated 300 to 350 humpbacks are present in southeastern Alaska during summer and fall (Baker et al. 1985). Aerial and shipboard survey data have been used to estimate that about 400 humpbacks summer in the Gulf of Alaska and Prince William Sound (Rice and Wolman 1982) and another 300 to 350 may summer near the Shumagin and Semidi islands. The number of humpbacks near the eastern Aleutian Islands is erratic but fairly low. Very few humpbacks have been seen in the Bering Sea since 1975 (Leatherwood et al. 1983; Stewart et al. 1987).

Over a 3-year survey period (1980-1982), an estimated population of 338 (+/-199) whales occurred in California coastal waters between Point Conception and the California-Oregon border (Dohl et al. 1983). As many as 100 whales were present in the Gulf of the Farallons during the summer of 1986 (Cubbage et al. 1986).

Incidental Takes in Fishery Operations

The extent of incidental taking of humpback whales by commercial fisheries in the North Pacific Ocean is unknown. Three humpbacks

were reported to be entangled in seine nets in Prince William Sound in the early 1980s (von Zeigesar 1984). Two or 3 humpbacks typically are reported entangled each year in gillnets and buoy lines in southeastern Alaska and British Columbia. NMFS Alaska Region received 7 substantiated reports of humpbacks entangled in gillnets in southeastern Alaska during the summer of 1987 (NMFS/AKR unpubl. data). Only one of those incidents resulted in the death of the whale. No estimates are available for the extent of unreported incidental take, nor are estimates available for the incidental take of humpbacks by commercial fisheries in other areas of Alaska. Two were taken in gillnets in 1985 off central California (NMFS/SWR unpubl. data).

Optimum Sustainable Population (OSP)

Current estimates of population size range from about 1,200 to over 2,000. This represents approximately 8% to 13% of the estimated pre-exploitation (pre-1905) population size of 15,000. Humpback whales are listed as endangered under the Endangered Species Act of 1973 and are depleted under the MMPA.

Effect of Incidental Take on OSP

Based on very limited information, it is believed that the number of humpback whales taken incidental to commercial fishing probably is small and that only a small proportion of these whales die. But, because of the endangered and depleted status of the population, and the lack of demonstrable population recovery following the ban on commercial whaling, even very small numbers of incidental kills may be significant.

Research Needs

1. Clarification of stock discreteness.
2. Estimation of population size.
3. Accurate reporting of incidental take and incidental kill.
4. Means to prevent or reduce incidental take and to mitigate its consequences.

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Gray Whale *Eschrichtius robustus*

Stock Definition

There are two stocks of gray whales in the North Pacific Ocean. The western stock which migrates between feeding grounds in the Sea of Okhotsk and calving grounds along the Korean coast, and the eastern stock which migrates between calving grounds along the west coast of Mexico and feeding grounds in the Bering and Chukchi seas (Rice and Wolman 1971). Commercial whaling severely depleted both stocks by the early 1900s. The western stock continues to be severely depleted (Yablokov and Bogoslovskaya 1984), but the International Whaling Commission (IWC) Scientific Committee concluded that the western North Pacific population still exists in small numbers (IWC 1986). The eastern stock has rebounded dramatically under the protected status designated by the IWC and prohibitions on whaling enacted by the U.S., Canada, and Mexico.

Distribution and Migration

Gray whales migrate biannually between their arctic foraging ground in the Bering Sea and adjacent waters of the Arctic Ocean to their subtropical calving ground in lagoons along the coast of Baja California and mainland Mexico. They generally follow a coastal route staying within a few kilometers of the Coast (Braham 1984; Herzing and Mate 1984; Poole 1984; Dohl et al. 1983; Rice and Wolman 1971; Pike 1962). Occasionally, they will migrate across inlets and embayments from headland to headland which takes them up to a few tens of kilometers offshore (Rice and Wolman 1971).

The exceptions to this coastal migratory behavior occur in the Southern California Bight, particularly during the southward migration (Dohl et al. 1983), and in the Bering Sea (Braham 1984). At Point Conception, the California coastline deviates from a generally north south orientation to an east west orientation. Perhaps two-thirds of the migrating whales fail to make this right angle turn (Kent et al. 1982). Some of these rather quickly turn back to the coast near Sacate, Santa Barbara County to rejoin those whales that followed the coastline around the Point. Others continue to follow offshore routes across the Bight that takes them over 150 km offshore (Briggs 1980).

The southern migration begins in early October and whales begin leaving the Bering Sea through Unimak Pass, Alaska in late October (Rugh 1984). Gray whales arrive in California waters in late November to early December (Dohl et al. 1983). Some immature whales fail to make a complete migration and are observed lingering in kelp beds (Wellington and Anderson 1978) in the Southern California Bight throughout the winter.

The northward migration generally begins in mid-February and proceeds in two distinct phases (Herzing and Mate 1984; Poole 1984). The first phase includes recently impregnated females followed by males, anestrous females and immature whales (Rice and Wolman 1971). The second phase comprises females with calves. Cow/calf pairs tend to follow the coastline closely and are often observed just outside the surf zone. Observations at Point Piedras Blancas, central California, show that the cow/calf phase of the migration begins at the end of March and continues through May. The cow/calf phase tends to peak at Point Piedras Blancas during the last week of April and the first week in May (Poole 1984).

Gray whales are seen returning to Unimak Pass and entering the Bering Sea in April. They begin returning to the vicinity of St. Lawrence Island in May and are most abundant there in June (Braham 1984). Braham (1984) believes that gray whales first concentrate to feed at the southeast and west ends of the Island and thereafter disperse north, west, and southwest.

Population Estimate

Based on a series of 13 censuses conducted from shore in central California during the south bound migration, Reilly et al. (1983) concluded that the gray whale population has reached, or is presently near its pre-exploitation level. They calculated a population estimate of approximately 17,577 (95% confidence limits 12,943 - 22,221) based on the 1979/80 census. The National Marine Mammal Laboratory, NMFS, has conducted more recent censuses during the 1984/85 through 1987/88 migrations which document the continued increase of the population. The most recent population estimate, for the 1987/88 migration, is 21,113 whales (Breiwick et al. 1988).

Incidental Take in Fishery Operations

The narrow corridor in which gray whales migrate results in a high probability that they will encounter and perhaps become entangled in gear from several fisheries. Norris and Prescott (1961) document entanglement in gillnets since the late 1950s. Stranding records maintained in the Northwest and Southwest Regions document that whales have been tangled in several types of nets, ropes and lines from pot fisheries, vessel anchor lines, and lines from other offshore activities.

Data from the NMFS-administered stranding networks document that gillnet fisheries take gray whales incidental to fishing. The Southwest Region of NMFS has maintained records of reported gray whale entanglements in California gillnet fisheries since the 1984/85 migration. The number of entanglements has varied from a low of 7 entanglements and no mortality during the 1985/86 migration to a high of 15 entanglements and 3 mortalities during the 1986/87 migration. The number of entanglements and deaths

declined during the 1987/88 migration to 7 entanglements and 1 mortality. This reduction in entanglements may have been due to regulations implemented by the State of California in the fall of 1987. These regulations require fishermen to construct their nets so that whales can break through them and prohibit fishing near major whale concentrations. However, no study was in place to quantify the effectiveness of these regulations and the decline in entanglement could be due to natural variation.

The California Department of Fish and Game (CDFG) has conducted several gillnet monitoring programs to determine the effects of gillnets on incidentally caught species, but has never observed a gray whale entanglement. Miller et al. (1983) observed one entangled balaenopterid, probably a minke whale, during 177 observer days spent monitoring the shark and swordfish drift net fishery in 1980. CDFG's southern California set net monitoring program monitored about 5% of the fishing effort during from 1983 through 1986 and observed no gray whale entanglements (Collins et al. 1984,1985,1986; Vojkovich et al. 1987). Likewise, no gray whales were observed entangled by CDFG set net observers in northern California during monitoring of about 1% of the fishing effort from 1984 through 1987 (Wild 1986a,b; Wild and Haugen pers. comm). Entanglements of gray whales probably are infrequent in northern California because fishing effort declines substantially during the migration season due to typically adverse weather conditions.

The NMFS' Southwest Region stranding network data base supports the conclusion that gray whale entanglements in northern California are rare. The Northwest Region stranding network data base indicates that salmon set nets off northern Washington and the Straits of Juan de Fuca entangle on the average about one gray whale every other year. Total mortality of gray whales in gillnets is probably less than 10 whales a year based on the data generated by the NMFS stranding networks and the CDFG observation programs. Precise estimation of mortality would require an expanded monitoring program.

Optimum Sustainable Population

Despite the presumed recovery of the gray whale population to pre-exploitation levels, it remains listed as an endangered species under the Endangered Species Act (ESA) and is, by definition, depleted under the MMPA.

Reilly (1981) estimated the carrying capacity (K) for the gray whale population to be about 24,000 whales. If the standard for determining OSP for eastern tropical Pacific dolphin stocks (> 60% of K) were applied to Breiwick et al.'s 1988 estimate of population size, NMFS would conclude that the gray whale population was at OSP (21,113/24,000 = 88%).

Effect of Incidental take on OSP

During thirteen consecutive censuses (1967 - 1980) the gray whale population increased at an annual rate of 2.5% (Reilly et al. 1983). Subsequent censuses conducted by the National Marine Mammal Laboratory, NMFS, document a continued increase in the population despite an annual subsistence take of about 179 whales for USSR Natives, a subsistence take of 1 or 2 by Alaskan Natives, and an incidental take of about 10 whales in coastal gillnet fisheries. This continued growth in the population indicates that the current level of incidental mortality is not affecting the population adversely.

Research Needs

Periodic monitoring of the gray whale population should be conducted to ensure the population is continuing to grow or remaining stable at an optimum level.

The distribution of whales and their use of habitat while on their winter calving grounds needs to be better documented. Censuses of whales in Mexican waters are lower than those conducted off central California (Reilly 1984). This may be the result of a disparity in survey techniques or a poor understanding of distribution and habitat use during the winter.

Gillnet monitoring programs should be improved to provide an accurate quantification of gray whale mortality incidental to fishing.

Information on entanglement should be collected to define the dynamics of entanglement and identify potential mitigating measures so that effective mitigating measures could be implemented if needed.

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